INTEGRATED CROP-LIVESTOCK-FISH FARMING

Food and Fertilizer Technology Center

Agriculture Building, 14 Wen Chow Street, Taipei
Taiwan, Republic of China
May 1980

FOREWORD

This book attempts to put into one volume country experiences and results of studies on integrated tricommodity farming system in some Asian countries, particularly those of China (Taiwan), Korea, Thailand, Malaysia and Philippines.

The growing concern today to maximize production through optimum utilization of resources has directed government efforts towards developing production systems and strategies that would give the maximum returns to the farmer producer. With limited possibility of expansion of land for cultivation in most Asian countries, the integration of crop, livestock and fish appears to be a logical approach towards this end.

While this system of farming has been existing in the rural areas, the advantages that can be derived from it have been widely recognized only recently. Undoubtedly, rural families have benefited from the system in the form of either additional income or better nutrition. To maximize the benefits that can be derived from tricommodity integration, there is a need to look into the practices that farmers employ, some of which may appear fundamentally unsound from experts' standpoints, and from there evolve a system that must fit into the farmer's resources, capabilities and needs as well as the socio-economic and agro-climatic conditions around him.

It was against this background that the Center sponsored the Symposium-workshop on 'Integrated crop-livestock-fish farming' which was held at the PCARR Headquarters in Los Banos, Laguna, Philippines on November 19—24, 1979. The articles contained in this volume, which were presented at the symposium-workshop, give an overview of the status of existing integrated farming systems in Asia and cover a discussion of the various concerns involved in the system. By putting all the papers together in a book form, we believe that the scattered information that has been generated in the various parts of the region will better serve the purpose of providing the much needed information on this emerging technology.

We would like to thank our co-sponsors, the Philippine Council for Agriculture and Resources Research (PCARR), Southeast Asian Regional Center for Graduate Study and Training in Agriculture (SEARCA), and the SEAFDEC-Asian Institute of Aquaculture, for the very valuable support and help that they provided in the arrangements and implementation of the symposium-workshop.

CARSON KUNG-HSIEN WU
Director, FFTC
May 1980

PREFACE

Tricommodity integration has been successfully demonstrated in the Republic of China, Malaysia, Thailand and several other countries in the region. Taken as a single unified farming enterprise composed of three complementary commodities, resource management and the interrelated technologies required by the system become more complex than a one-commodity farming system.

Waste recycling, the key feature of the system, provides for optimum utilization of resources and offers a three-point advantage over the other systems: it does not only increase farm incomes but also control pollution, enhance and conserve other resources that would otherwise be used for the same purposes.

Integrated farming systems are in various stages of development in the region. With most practices still traditional in nature and without much scientific basis, the focus in most Asian countries has been on applied research that would make the system an economically viable enterprise for the farmer with a small land base and surplus labor.

The papers included in this volume indicate the complexity of integrated crop-livestock-fish farming and point to the need to evolve systems that are location- and situation-specific. The country case reports (i.e., Taiwan, Korea, Japan) also bring out the significance of farmer's associations and government support services in the successful operation of the enterprise. From the discussions and papers presented during the symposium-workshop, several important issues have emerged:

— Analysis of the nature, availability and distribution of the environmental and socio-economic resources is essential in determining the most beneficial cropping pattern or farm enterprises to be pursued in a given situation.

— While multicommodity farming may offer more advantages than monocropping systems, the introduction of more commodities will require new management skills and give rise to less uniform recommendations. Thus, the technologies must be verified at the farm level in specific locations and situations under various agro-climatic zones.

— The development of a systematic cooperative marketing scheme through the farmer's associations should be a major concern of any project. The organization of farmer's associations could overcome the limitations to wide adoption of integrated farming. In small-scale individual operations, complementation among the commodities is possible, but as farm enterprises become more diversified and larger in scale, the relationships tend to be competitive.

— There is definitely a need for more applied research to verify existing practices for technology packaging and dissemination and for extension work oriented towards the small farmer.

— There is a need for training of farmers as well as rural women on integrated farming system to prepare them to receive the new technology and the management skills that go with it; similarly, a training for government officials and extension workers is needed to reorient them towards an integrated approach of providing services to small farmers.

We have also included in this volume the pre-feasibility project studies developed by the participants for each integrated farming with either crop, livestock or fish as the principal commodity. Some basic assumptions were made since the groups were confronted with the difficulty of making specific recommendations considering the complexities of variables involved. Several important comments were brought out during the presentation of these studies by the groups, but because of limited time, these comments and other changes have not been incorporated in the original outputs. Nevertheless, we hope that these pre-feasibility studies would serve as a guideline to those who would have opportunities to go into integrated farming and would need to develop project proposals to operationalize the system and show its economic viability.

A word of appreciation is due to all the participants who have taken time to write on the topics assigned to them and have actively participated in the discussions. As a space consideration, most of the papers presented have had to be condensed. Special thanks are due to Dr. Elvira O. Tan, Director, Fisheries Division of PCARR, and her staff for taking care of the local arrangements before and during the seminar-workshop, to the Secretariat for patiently documenting and summarizing the discussions for each day, to Ignacio Pagsuberon of PCARR's Applied Communication Division for preliminary editing of the papers, and many others who shared their time, talent and expertise.

Milagros H. Tetangco
Editor

ASPAC-FFTC
May 1980

CONTENTS

214 IMPERATIVES FOR AN INTEGRATED CROP-LIVESTOCK-FISH FARMING SYSTEM

by

Joseph C. Madamba

INTRODUCTION

A multi-commodity farming system presents more advantages to farmers than a mono-cropping system. However, the commodity mix must fit into the particular farmer's capability, resources, and needs as well as the social, economic and environmental forces around him.

While a crop-livestock-fish farming system appears to be, and indeed is a very attractive innovation, its management is not going to be as easy as it looks. It is ... a mere addition of one or two more commodities to the farmer's existing crop but an entirely new farming system which requires a new set of technological introductions and management skills. Also, as you increase the number of commodities you will find that you are decreasing the latitude for uniformity of recommendations.

We must recognize that in the Asian setting, most farmers rarely operate a one-commodity farming system. In this, they are well ahead of us. And the fact that they have survived shows that they have fairly well managed a multi-commodity farming system, however primitive and unprofitable from experts' standpoints their way of doing it may be.

Our three-fold task therefore is simply to find ways to improve on the system, to develop acceptable and appropriate tricommodity farming systems for areas and farms that do not yet, but have the capability to, put into application this kind of enterprise, and to find ways to promote this system of farming.

Some Previous Findings and Recommendations

An expert group meeting convened by FAO in Bangkok in June 1976 discussed several case studies on crop-livestock integration at the small farm level[1].

Some of their findings include the following:

1. A need to reorient programs and policies biased towards the small farmers.

2. Failures in development traced to inappropriate policy– for instance, pursuance of monoculture or single activity approach; inappropriate borrowed technology to suit large scale or commercial production without any consideration for local potentials; inadequate knowledge for exploiting local resources among the technicians and neglect of indigenous knowledge and inputs; adaptation of technology that would create almost permanent dependency on industrialized countries; institutional deficiencies specially land institutions; and lack of suitable support service and failure to understand human resources as a major form of capital available in agriculture.

3. Crop-livestock integration is the most effective and possible way to help the small farmer who has a small landbase but surplus labor.

4. The wide differences in the region's agro-climatic situations, as well as differences within the countries themselves, would require the formulation of different sets of activities to suit these various conditions i.e., heavy rainfall areas, dry areas, hill areas, lowlands, uplands, and tree-crop plantations.

5. It was also pointed out that there are several animals and fowls that have not received due attention.

The same group of experts recommended the following which we may find relevant to our problem:

Firstly, there must be fuller utilization of local crop by-products as it is one of the most promising means by which water buffalo and goat production can be produced economically with a limited landbase. It was however, recognized that constraints, such as lack of suitable technology, lack of the required mechanism for supporting services will have to be overcome before these programs can be successfully implemented. The experts noted that labor intensive production systems should be emphasized considering the available surplus labor in the family farming system.

Secondly, a cropping pattern and livestock integration plan should be worked out in consultation with the farmer who has to implement the plan.

Thirdly, in working out an integration system, attention must be given to the total farm resource (i.e. feed and fodder in the case of livestock integration into a cropping system) of the farmer; we should consider the farm by-products, their collection, treatment and conservation; and

Fourthly, they suggested for national institutions to look further into small farmers' problems and develop suitable technology applicable to the small farmer and farm laborer family production system.

INTEGRATED-CROP-LIVESTOCK-FISH FARMING SYSTEM AS A TECHNOLOGY PACKAGE

McInernev[3] gives three criteria for an innovative project to be successful: a) it must generate economic effects sufficient to justify its adoption in terms of what he calls the conventional appraisal calculus; b) it must create social and distributive effects consistent with the rural development strategy; and c) it must promise a continuing development effect which sustains change in a desired direction throughout the rural system.

Three requirements have been identified to meet these criteria for success. First, a technological package suited to the particular development purpose; second, a rural system conducive to the reception and adoption of this technological package; and third, management of the ensuing change process on a continuing basis. It is assumed that the generation and adoption of new farming technology cannot be left entirely to chance and must therefore be fostered by concerted policies and investment activities on the part of national government and development agencies.

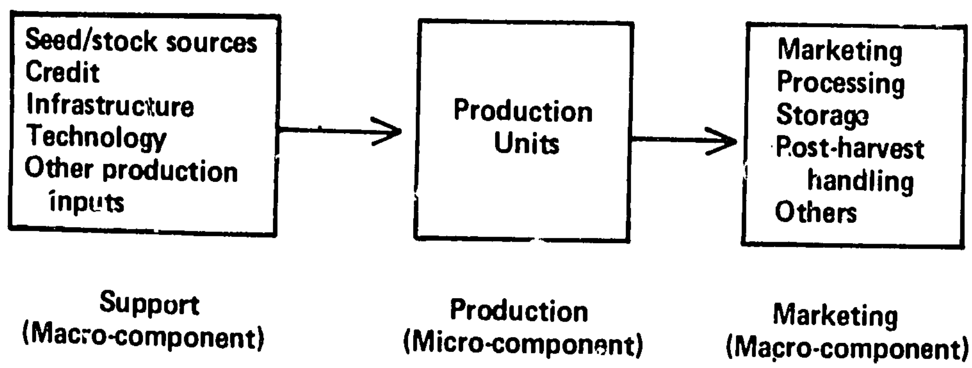
We are reminded that the first requirement for successful innovation is the availability of a package of technical components that is complete, reliable and properly designed for the condition within which it is to be applied. Second, the package of technology must be consistent with the human attributes, attitudes and abilities in the region since farming is not solely a technical system but is one in which social attitudes have a pervasive influence. A third requirement is to include an information component in a development project. This is based on the fact that innovation represents the introduction of novel inputs and methods into the farming system, therefore, a project may be ineffective or even dangerous in the absence of appropriate knowledge, or even in an incomplete form. Finally, it is deemed essential that newly introduced technology must have a high probability of technical success at its first trial, and must be perceived to offer reliability. This is certainly necessary to protect the welfare of the innovating farmer and to serve as an effective demonstration to encourage adoption and continued use.

THE EVOLUTION, TRANSFER, AND MANAGEMENT OF TECHNOLOGY PACKAGES FOR A TRI-COMMODITY FARMING SYSTEM

From these observations, recommendations, and expert opinions, one essential consideration seems to stand out: technology that should finally be promoted for adoption must itself be evolved from the farms with the participation of the farmers themselves. This would take care of the requirements of location and situation specificity; its having to be shaped by the existing socio-economic conditions and farmer's attitudes; and its being simple enough and tailored to fit the management environment and resources of the farmer. A mechanism is therefore needed to institutionalize and coordinate among our countries or within national systems the evolution and transfer of appropriate integrated tri-commodity farming systems for different rural situations. This calls for a concept and a machinery to integrate the technology with the general scheme and mainstream of area development activities now going on in various countries.

Resource Management Concept

It is suggested that we look at the integrated farming system in terms of an industry model. In this respect, we are borrowing from a model which has been developed for the aquaculture industry. Designed as an industry development support scheme, the model consists of three components, namely: the production support component, production component, and marketing component. Treated in the context of an industry system, the production support and the marketing subsystems are the macro components while the production subsystem– which in the model consists of the various individual integrated farming system enterprises– is considered and treated as the micro-component (Figure 1). The macro-components consider the various elements in the production support and marketing systems, while the micro-component considers the process by which production may be increased effectively and more profitably.



Production support includes the delivery and provision of production inputs like seed or stock, feeds, fertilizers, credit, the technology component and relevant information about it, and the industry infrastructure. The production units are essentially composed of the farmers themselves who would have to be organized into associations or cooperatives. The third subsystem includes the post-harvest handling and treatment, marketing, processing, storage and distribution of the outputs. This component would enable the producers to take optimum advantage of market opportunities.

While the scheme could be worked out at the village level, it can very well be translated and operationalized into a wider area development project. It would need an integrated approach to the development of the tri-commodity-based farming systems. Such an integration will be worked out by the various institutions that provide the different support services as identified in the model's two macro-component systems, i.e. extension, research and development, markets, farm suppliers, banks and lending institutions etc.

A mechanism to link the production units back to the production support system and forward to the marketing system would have to be forged for an integrated area approach to integrated farming systems development. The nature and function of such linking and integrative mechanisms must consider the proposition that the tri-commodity farming system is a single unified farming enterprise composed of three complementary commodities. While it sounds easy to put this into a conceptual form, the possibility arises for integration to be doubly complicated by the competition among the three commodity components for resources, both within a single enterprise and, more especially, among tri-commodity farmers in a given area. This problem will have to be partially resolved by thorough economic studies on the comparative profitability of the different commodities that compose the farming systems and by a rigid testing of the technology component of the entire technology package.

This would necessarily involve the setting up of technology verification and packaging programs as an integral part of the development aspect of the tri-commodity farming technology. We must remember that in testing the effectiveness and appropriateness of a multi-commodity farming system, one must test the individual commodities that compose the system not in isolation but in combination. A pilot project can in fact include the technology verification function.

Results of verification studies then can be packaged and refined further for subsequent recommendations to farmers in the areas whose situations, conditions, and socio-economic patterns are similar to where the tests had been conducted. As I said at the start, the more commodities there are for a farming system, the less uniform will be your recommendations. Location-specific and situation-specific technology verification studies can take care of the differences. Technology verification in the context of pilot program would not only provide the technology package but would also, to a large extent, test out various collaborative mechanisms among the service and support institutions. One of the biggest conflicts I can foresee will occur among these institutions especially if policies are non-existent or vague on the aspect of coordination. As it is, some programs provide emphasis and, therefore, more support for certain commodities. It will have to be emphasized to both policy makers and service institutions that we are dealing with an integrated farming system, not with individual commodities that happened to be mixed together.

For specific activities and support services, the same expert group meeting convened in Bangkok forwarded the following recommendations:

For management, they agreed that small farmers and agricultural laborers find new technologies and management practices alien to their needs and understanding. For this, they recommend the development and promotion of simple and low-cost management practices.

In training, the experts emphasized on the need to make training programs practical and aimed at real-problem solving for village-level workers. The trainees must be exposed thoroughly to local problems and prospects of small farm producers. It was suggested that training programs should be conducted in the village and in farmers' household areas. Further, the training for small farmers to prepare them to receive new technology and management skills should be enhanced; and government agencies and officials as well as the extension staff must also be reoriented towards the new approach of providing services to small farmers in an integrated, instead of discrete or piece meal, manner.

As to the support services, the recommendation was to provide credit, marketing and extension through group organizations. This recognizes the well-known observation and fact that individually small farmers have a weak bargaining power. One recommendation is to have special credit programs earmarked exclusively for the small farmers. On top of this, it was suggested that appropriate price policy measures for the farm products (i.e. livestock) be adopted to encourage their production at the small farm level.

Again, extension services should be provided in an integrated manner as a package to avoid confusion due to multiplicity of extension agents.

THE TRI-COMMODITY FARM BUSINESS

A very simple but appropriate model has been drawn by Dr. A. T. Mosher[4] to help us take a closer look at an integrated farming system as a business. The farm business, says Mosher, is really a combination of farm enterprises which 1) support each other, 2) distribute labor requirements, and 3) jointly determine farm income.

Mosher reminds us that the farmer cannot simply select individual enterprises for his farm business without considering them in relation to one another. These enterprises are full of 'joint products' and 'joint costs' (i.e. a cereal crop also produces straw for feeding livestock; manure from livestock may be used to fertilize cropland, etc.), which would then preclude the separation, both in the accounting sense and in the research and development sense, of the enterprises that compose the farm business. According to Mosher, each farmer would try to work out the best combination of crop, livestock, and fish enterprises for his own farm business, considering the land, labor, and other resources available to him. Similarly, so would research and development, particularly the aspect of technology verification.

The complexity of the integrated farm business stems from the farmer's choice of the enterprise. His choice is generally influenced by how he thinks of the costs and returns– whether in terms of the cash value of the harvest or in relation to his position and responsibility in the rural community.

On the other hand, Mosher adds that if the farm family consumes most of the products of its own farm, its need for the food in its customary diet and for other products of the farm will be the major factor in its choice of farm enterprises. And, to the extent that products are grown for sale, the choice of enterprises will be influenced by the accessibility of markets for different products and by their relative market prices. Finally, a farmers' opportunity for off-farm employment may also influence how he uses his farm and what enterprises he chooses.

In other words, the farm product mix may not only be influenced by purely economic forces but by sociological factors. It would be necessary therefore to find out what product mix would best satisfy the farmer's socio-economic requirements. This would of course, be in addition to what would be technically feasible and offer a greater advantage for the farm family. However, while it may be attractive and quite economically logical to think of costs and returns, we may run against a wall of resistance if we insist right away in promoting a tri-commodity system where one or two of the product mix do not fit into the farmer's production activity patterns. This is where one needs a program to introduce into a locality the technology package with a provision to gradually prepare the farmers to receive such technology. For, while technology must be tailored to the needs and conditions of the intended adoptors, the conditions and receiving capacity of such adoptors can also be modified to an extent that the technological package can fit well into the overall socio-economic and technical environment.

A well-designed farmers' training program which is closely tied in with a strong communications as well as extension-support system could effectively provide an atmosphere for technology reception and thereafter sustain its adoption.

Linkages

To keep the production units in business, a strong linking mechanism to the various institutions serving them is necessary. The linkage should allow not only for the delivery of services but for the constant monitoring of the requirements, activities and reactions of the various production units.

At the area level, (defined by geographic boundaries within an agro-climatic zone) it would be essential to find out and constantly monitor the total available resources for the production units. This would provide an up-to-date guide for the assessment of the potential production capacity of the farms within the area vis-a-vis the available resources, which in turn would help in the formulation of management decisions in regard to the optimum use of these available resources. While an integrated farming system is supposed to make the most efficient use of all available farm resources, the reality of it is that some resources will not be as abundant as others and therefore will have to be supplemented by inputs supplied from outside the system. For most small Asian farmers, such inputs are not cheap and easy to obtain. To keep them viable we must look into the provision of these needed inputs in the proper amount, timing, and at reasonable costs.

Farmers' Organizations

Technology packages introduced into a development program stand a greater chance of acceptance and establishment if the community were to be involved in the development of the package, and the design and implementation of the program. This is one of the important recommendations in the expert group meeting in Bangkok on crop-livestock integration. The Comilla District experience on an integrated rural development program has shown that a strong local authority can elicit better participation than officials who represent and are responsible to a remote authority. Generally, a strong farmer's association would enhance, first of all, their bargaining position and, of equal importance, would enable the farmers to take advantage of the market opportunities. As Dr. Librero[2] pointed out in a study of the Philippines' aquaculture industry, the small farmers are mostly the victims of the vagaries of the market because they lack withholding power, which means the ability of producers to restrain productivity in the market when prices are unfavorable.

As pointed out earlier, another reason for farmer's organizations is to have a central point of contact for the provision of services (such as credit) whereby the organization will have a collective responsibility for the proper utilization and repayment of loans. Information delivery and training schemes would be, of course, enhanced if they involved an organized group with common problems, interests, and needs. The final reason is that these organizations are going to provide the management inputs for the production units in an integrated industry development scheme as described in the model.

SUMMARY

The need to utilize more efficiently available farm resources has led to the increased attention towards farming systems that integrate more than one commodity. The tri-commodity (crop-livestock-fish) farming system is the latest thrust among the integrated farming concepts and holds a great deal of promise for the small Asian farmer.

For successful implementation of this practice in the rural Asian setting, the following requirements are needed, aside from having a good and proven technological package:

1. The technology for this farming system must be verified at the farm level in specific locations and situations under various agro-climatic zones;

2. While the technology package must be tailored to the farmers, the situations and conditions at the farmer's level may have to be also modified where appropriate to enhance the reception and application of the technology;

3. Integrated tri-commodity farms could best operate if they were placed into the mainstream of area development. To do this effectively would need an approach designed to bring the small farming units into a scheme in which they are an integral part of the agricultural industry of an area. In such a way, efforts are organized and coordinated among the various institutions to provide the needed support services for production and marketing; and

4. Finally, to provide a strong base for the application of the integrated farming system technology, farmers must be organized into strong production units and be provided, through effective training and extension programs, with a capability to fully utilize the technology as well as manage the program.

REFERENCES

1. FAO/UNDP. 1976. Expert Group Meeting on Livestock Programs for Small Farmers and Agricultural Laborers, Proc., RAFE, Bangkok, Thailand.
2. Librero, A. R. 1978. 'Aquaculture Development for the Rural Poor: Past/Present Trends and Future Consideration.' Presented at the Regional Workshop on Aquaculture Development Strategies for Asia, August 6–13, 1978. Manila, Philippines.
3. McInerney, J. P. 1978. The Technology of Rural Development. World Bank Staff Working Paper No. 295. The World Bank, Washington, D. C. USA.
4. Mosher, A. T. 1966. Getting Agriculture Moving. Frederick A. Praeger, Pub., N. Y.

RESOURCE UTILIZATION IN INTEGRATED FARMING SYSTEM WITH CROPS AS THE MAJOR ENTERPRISE

by

Diosdado A. Carandang

INTRODUCTION

An integrated farming system seems to be the answer to the problem of increasing food production to increase the income and improve nutrition of the small-scale farmers with limited resources. Researchers on specific crops do not usually consider the resources until the crops are tested in farmers fields. Researchers on farming system, however, demand that the resources of the farmers be given major emphasis so that the technology can be accepted. Thus, resource utilization should be considered together with the technology in arriving at an improved farming system (Fig. 1).

In this paper, I would like to consider the various resources for cropping systems enterprise and present some data or examples to show how the particular resource is manipulated or maximized.

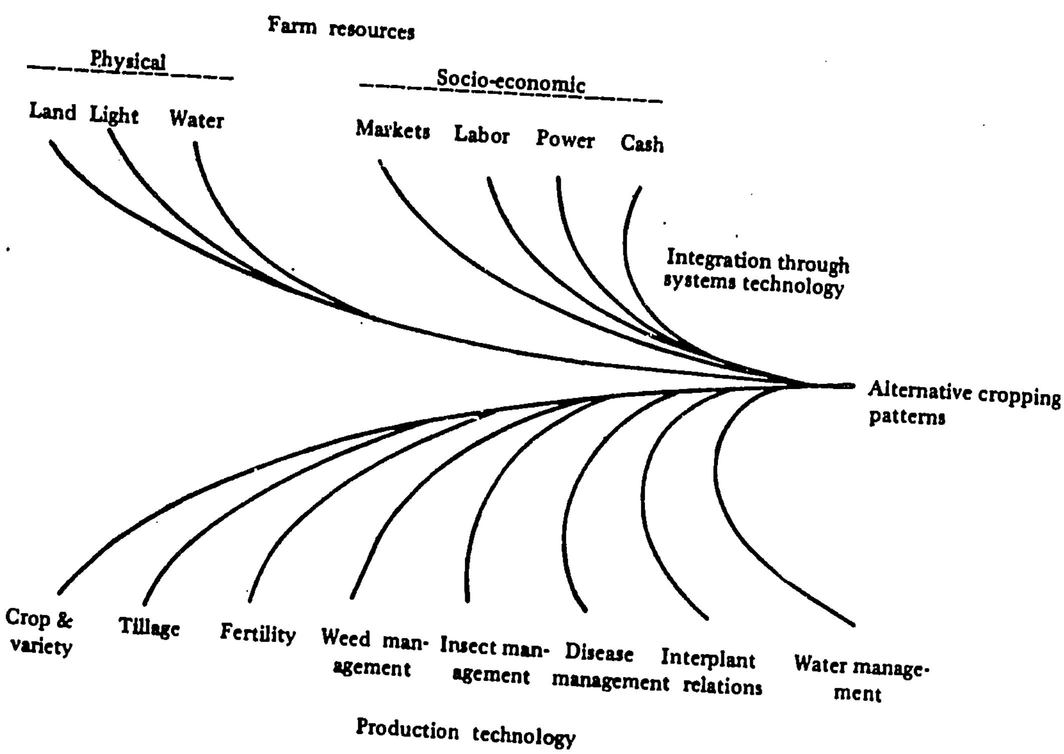


Fig. 1. Conceptual outline of the cropping systems approach

The various resources available to crop-oriented farming systems are not, nor should they be set aside for crop production only. The various resources should be utilized for the cropping pattern or farm enterprise which will provide the maximum benefits or return to resources. If the resources would provide better return through fish production, it would be unwise to use it for rice production. The risk factor should also be considered because small-scale farmers are the ones who cannot afford to take too much risk.

RESOURCES AVAILABLE

The resources can be divided into physical or natural and socio-economic resources.

Physical or Natural Resources

Land– Each farm unit has a certain amount of land of a given topography, soil physical and chemical characteristics. The utilization of this land resource ~~is~~ however, dependent on the other resources. The topography influences the water availability and would therefore affect the particular cropping pattern to be used. If the land is dependent on rain, then the topographic feature will determine the cropping pattern and ultimately the intensity of land use. We can visualize four positions in the slope as shown in Fig. 2. They are: high interior bund, high side bund, intermediate bund and low bund. Let me just expound on two of them.

High interior bund would be a paddy with no outflow or inflow. Heavy rains can infiltrate or runoff, resulting in waterlogging. These paddies cannot be recommended for early upland crops but it cannot accumulate enough water for early land preparation. The most intensive pattern would be a dry-seeded rice-wet seeded rice-sorghum. At the lower bund, there is inflow but no outflow. This paddy would be used exclusively for rice with an upland crop at the beginning of the dry season.

Water– Water is an important resource such that, we usually classify our land into a rainfed or irrigated land. At present, irrigated areas are intensively cultivated to lowland rice. The intensity of cropping maybe two or possibly three crops per year although irrigated land is generally used for two crops. In rainfed areas, generally the lowland rice is followed by an upland crop. This practice depends on the monthly distribution and pattern as shown in Figs. 3 and 4. Where the monthly rainfall reaches 200 mm lowland rice can be planted either through dry-seeding or transplanting. One or two crops of lowland rice is possible depending on the number of months of rainfall. Two or three crops of upland crops including upland rice can be planted if the monthly rainfall is less than 200 mm or about 100 mm. The intensity of land use therefore is dependent on the number of rainy months and the amount of monthly rainfall.

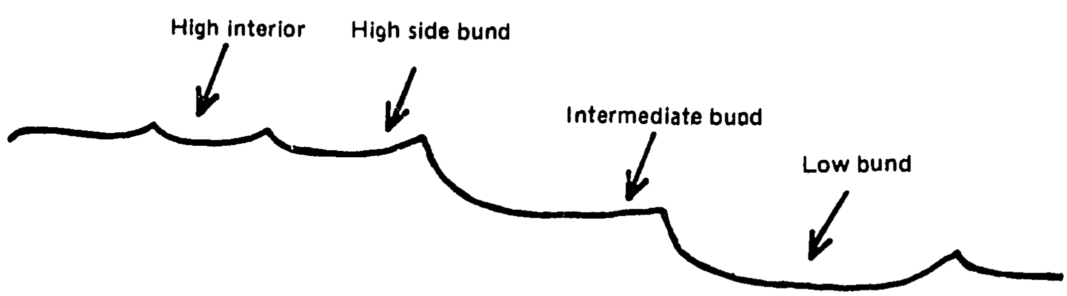


Fig. 2. Four positions in the slope

Sunlight– The amount (duration and intensity) of sunlight is a critical factor. In a monsoon climate light intensity is often quite low during the rainy months. This sharply limits yield and response to inputs such as fertilizers, pesticides and highly productive varieties. To maximize utilization of this resource, timing of planting as well as various methods of cropping should be used. Theoretically, the best time to grow the crops would be during the summer months when the light duration is long, and intensity is high. Unfortunately, this is also the months when water would be limiting.

Rapid sequencing of crops, relay planting and intercropping may be used for maximum utilization of sunlight. Intercropping can increase light interception by as much as 30–40%. In coconut areas, where the trees are old and tall as much as 50% of the sunlight reaches the ground without being utilized. In this instance, intercropping with annuals or even perennial crops would increase the utilization of both land and sunlight. While sequence cropping should improve the utilization of both land, water and sunlight, land preparation or turn around time can seriously affect the timing especially when the sequence involves lowland rice-upland crop.

Socio-Economic Resources

Labor– One of the strong justifications for intensive land use is the presence of excess farm labor. Usually, labor utilization and productivity are closely related to the type of cropping pattern used by the farmers. Various crops or crop combinations have different labor requirements (Table 1 and Fig. 5). It is also of interest to note that the harvest and post-harvest labor requirement varies. The proper combination of crops therefore is needed to assure that labor would be adequate. The other factor, however, that should be considered is the labor distribution. The different crops after irrigated rice (Fig. 6) showed different peaks of labor. As cropping intensity increases, uneven demand for labor results. Seasonal peak demand restricts the level of cropping intensity due to temporary labor shortages. This is important because while there is excess labor in the farm, labor requirement may not be distributed evenly.

Table 1. Labor requirements of different crops or crop combination

Crops/cropping pattern	Man-days/ha.
Sweet potato/corn	112.9
G. corn-cowpea	31.4
Peanut	111.7
Soybean:	
TK-5	57.9
Multi-Var-80	39.1
Mungbean	92.4
Cowpea (green)	192.9
Sorghum (main crop)	67.7
Ratoon	30.7
Corn	30–42

oon
ɔnse
this
ılly,
ɔng,

tion
eas,
zed.
ı of
ater
the

ɔor.
by
.5).
ɪper
tor,
Fig.
ılts.
is is
ted

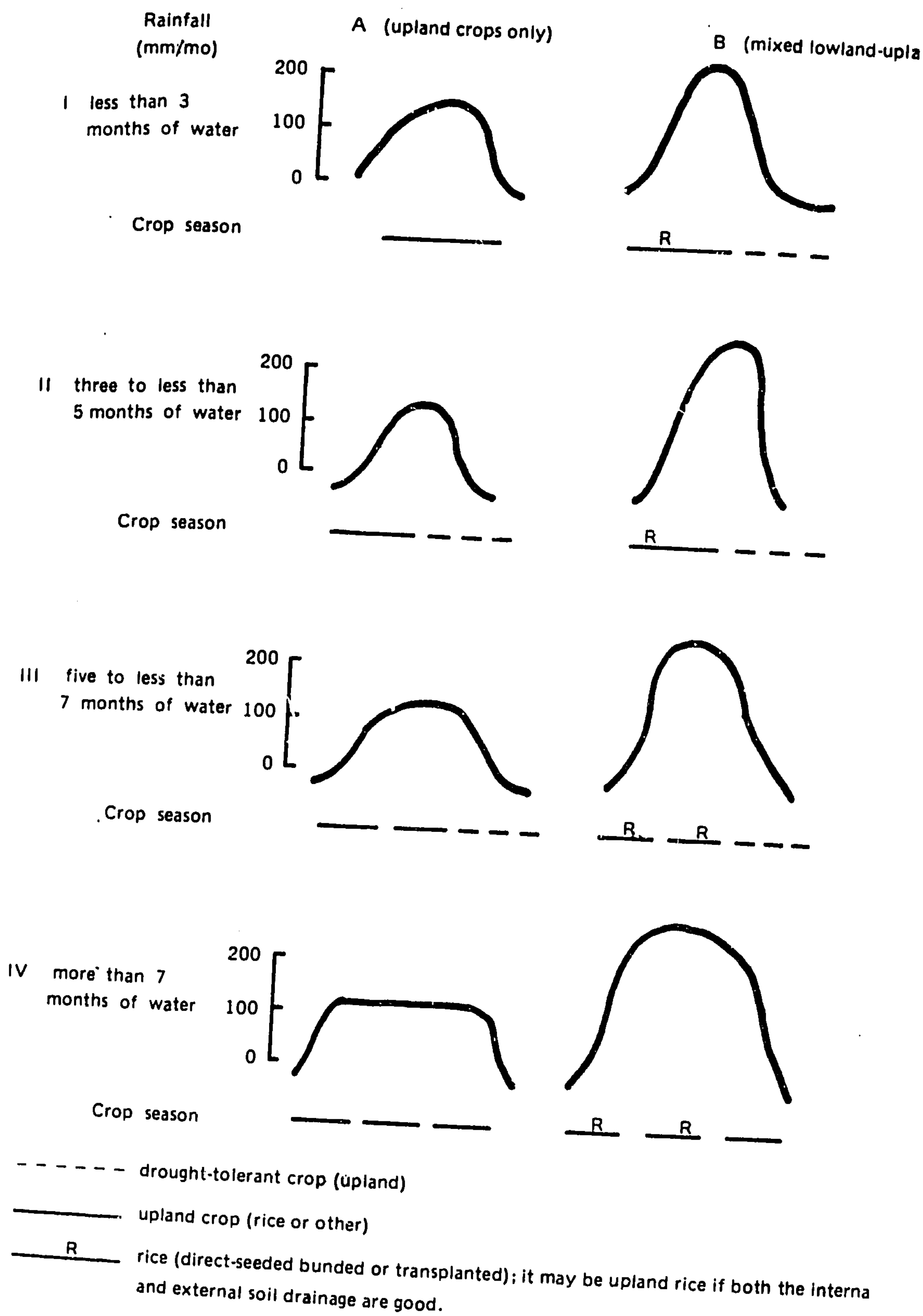


Fig. 3. Crop season potential for different water availability groupings.

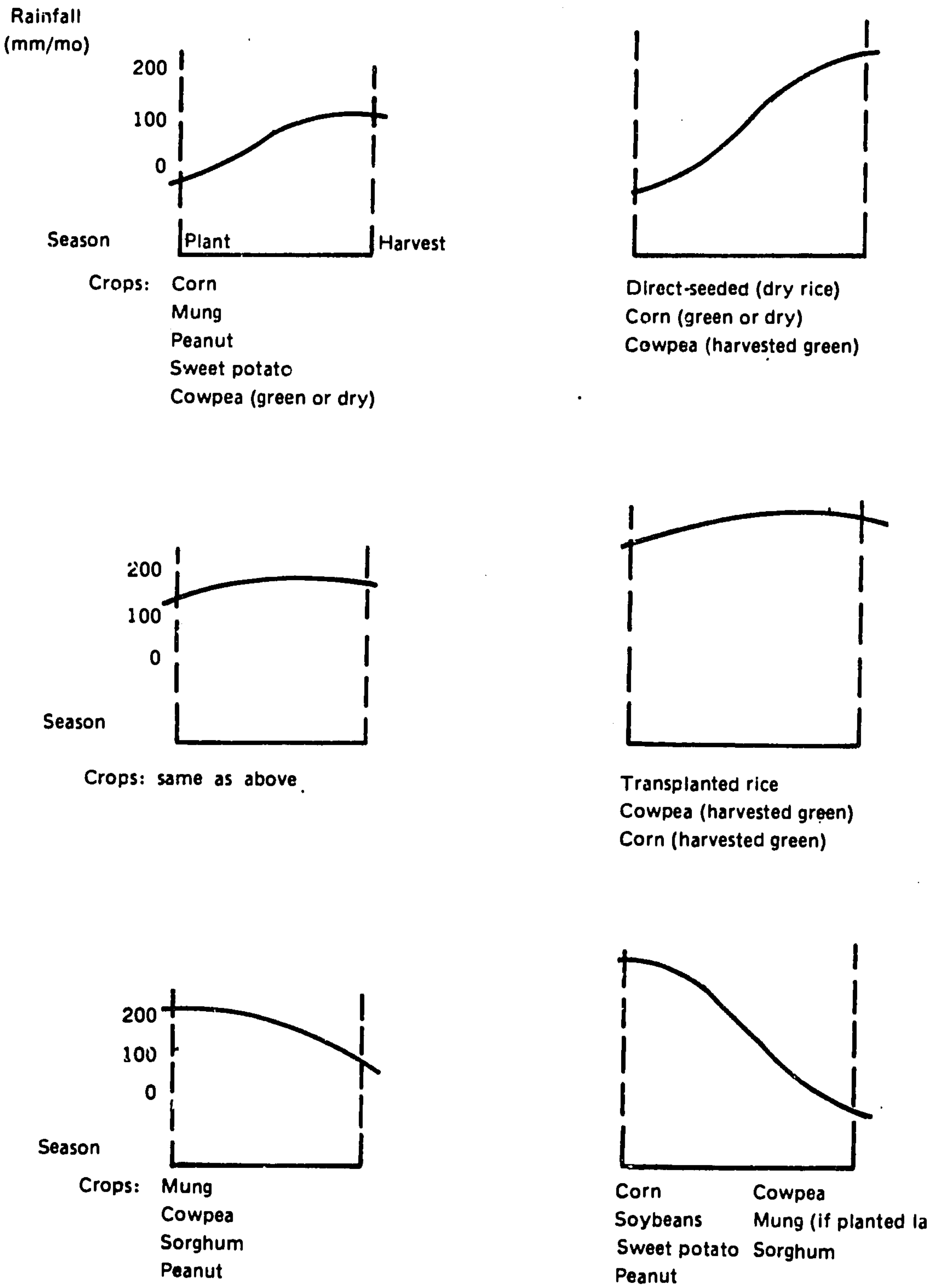


Fig. 4. Crop suitability for different water availability regimes.

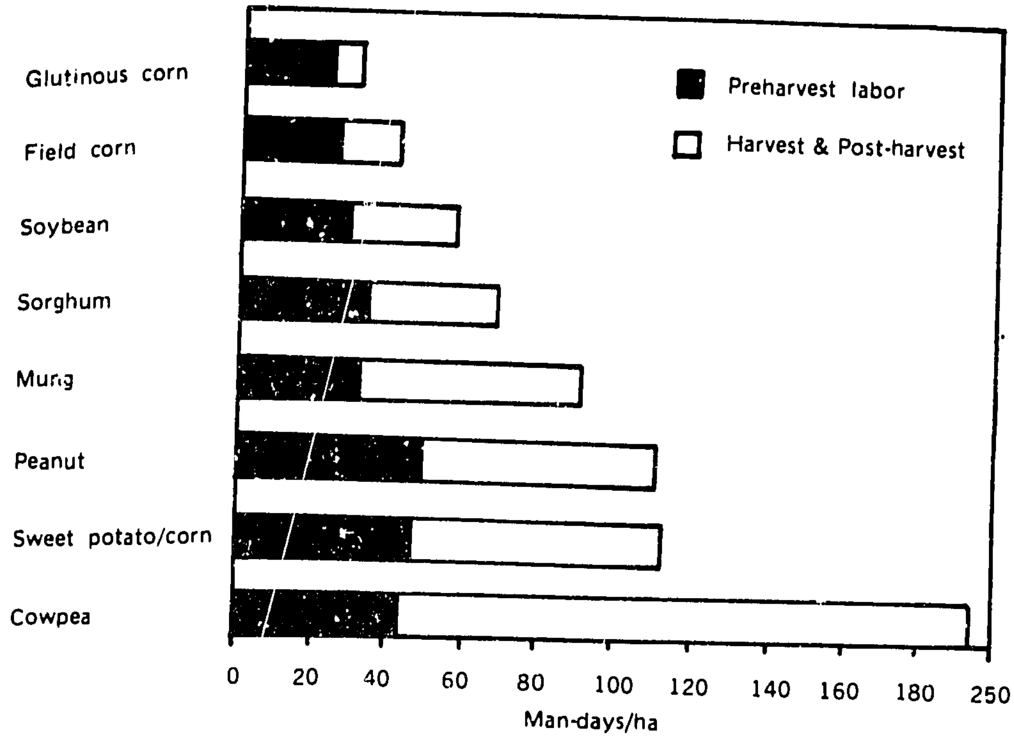


Fig. 5. The average labor requirements of each test crop, Batangas, late wet season, 1974–75.

Cash or credit– One of the reasons rice farmers in the Philippines are better off today is availability of credit. Where intensive cropping is practiced, inputs such as seeds, fertilizers, chemicals and other farm operations will need cash. For many small scale farmers, credit is the only way to get the inputs. The amount needed and the length of time that credit is needed will depend on the farming systems used. Tree planting will of course require the longest and possibly the highest credit. In a study of six irrigated cropping patterns discussed earlier the credit requirement varied resulting in different costs of credit (Table 2). Another study in farmers' field in Batangas (Fig. 7) confirmed this. The cash requirement varied from ₱ 300 to about ₱ 800. Thus, the farmers' decision will be greatly influenced by cash requirement and availability.

Table 2. Cost of credit for six irrigated cropping systems[a]

System	Amount borrowed (₱/ha)	Weeks borrowed	Cost (₱/ha)
A	640	10	16
B	1580	27	107
C	1560	16	62
D	550	14	19
E	560	23	32
F	1800	23	103

[a] Assuming total amount of credit needed is borrowed at beginning of season paying 13% interest per annum. 1US$ = ₱7.35

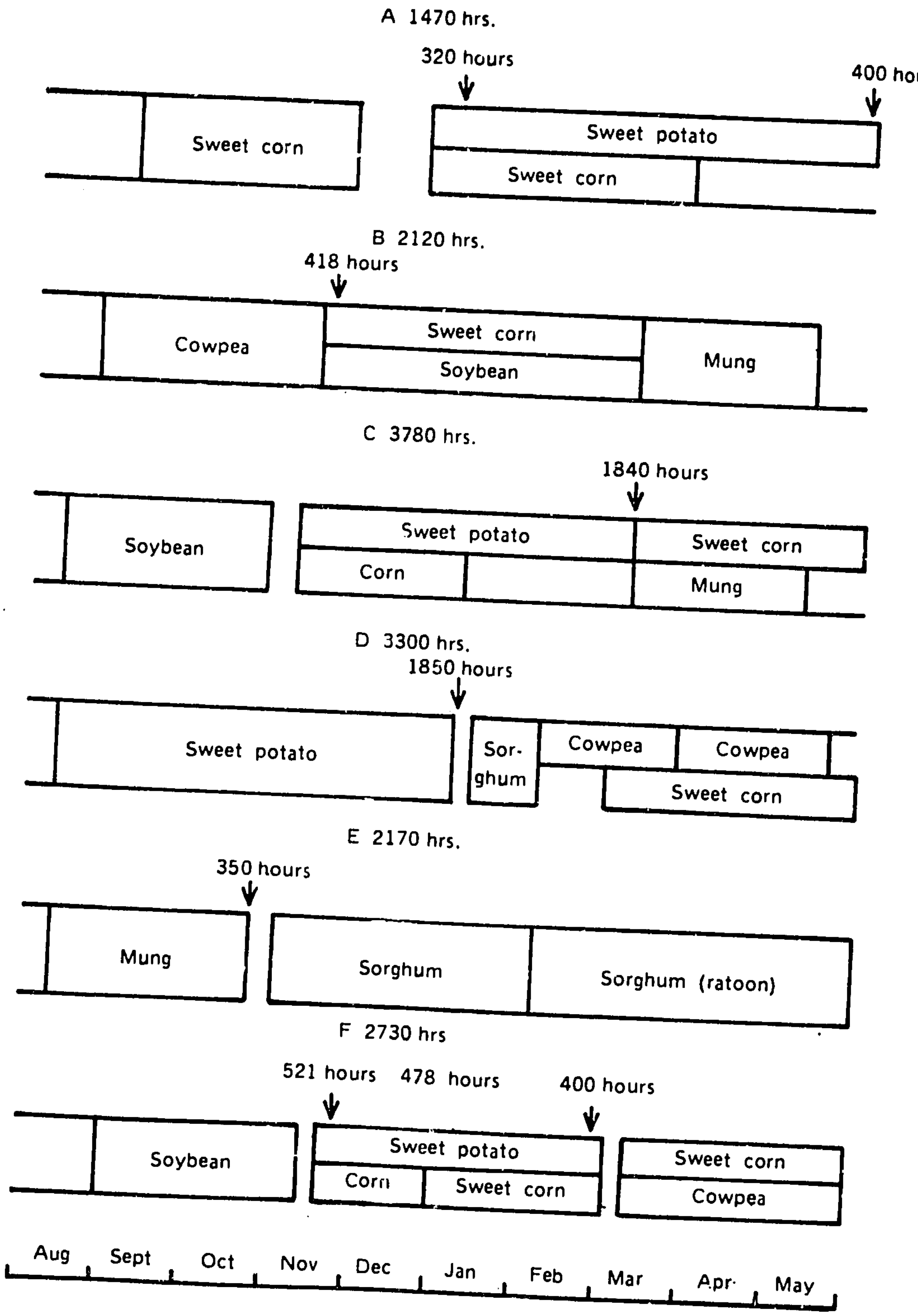


Fig. 6. Total and peak labor requirements per hectare for six cropping systems, listed in order of decreasing net return (arrows indicate peak labor requirements).

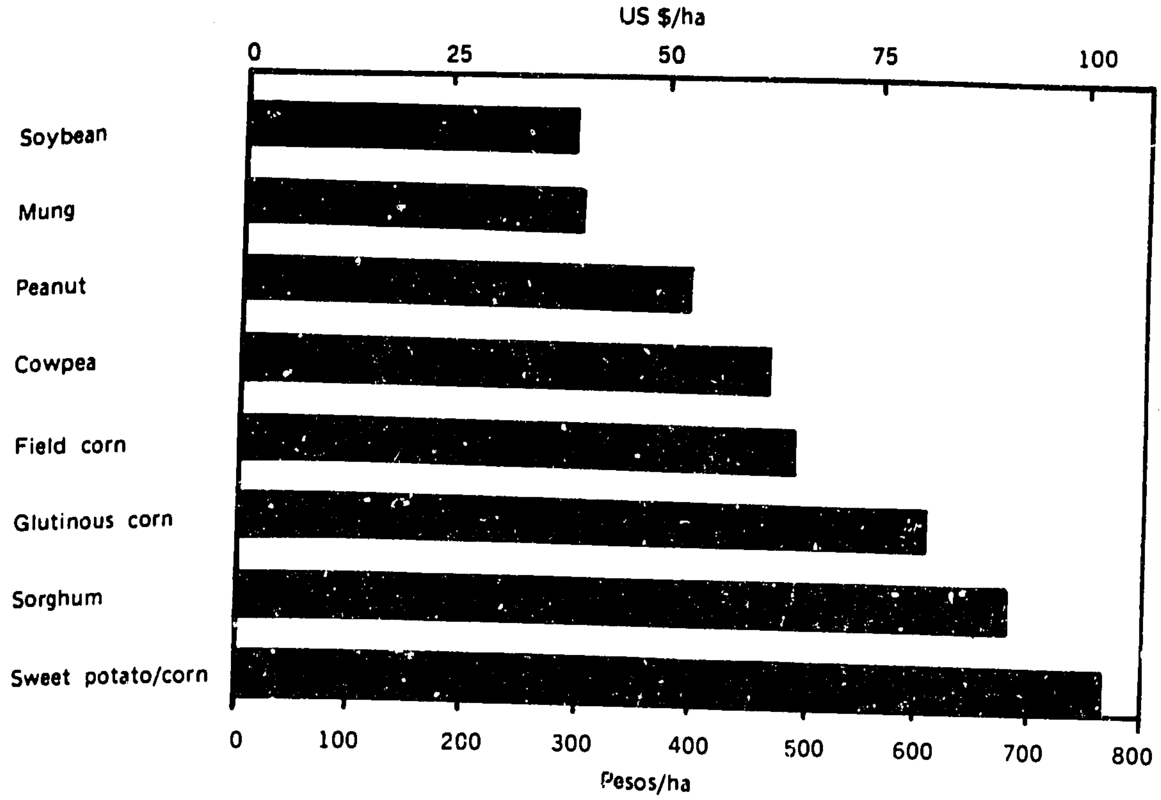


Fig. 7. Total cash costs per hectare of each test crop, Batangas, late wet season, 1974–75.

Power source– The power that a small scale farmer has may determine the type of cropping pattern to use and the intensity of land use. A common question is whether to use small tractor or to use draft animal. The type of cropping system most efficient in a hand operation may not be particularly well suited to animal power or an animal-oriented pattern may not be suited to small hand tractors. In Indonesia for instance, extensive intercropping has been attributed to lack of farm power in the area. On the other hand, Bradfield has shown that an intensive cropping is possible if a hand tractor is used which otherwise may not be possible if only hand or carabao is available as a power source.

Banta[1] compared the power sources, i.e., man, carabao and hand tractor and his results demonstrated that the carabao and in certain instances, the hand labor is economically competitive with the hand tractor even in systems designed for the hand tractor. However, the time element makes it unrealistic (Fig. 8). Where only three men will work, additional two months are needed to complete the pattern. Mechanization tends to smooth out the peak of seasonal demands for labor permitting a greater degree of intensification and more rapid turn around.

Markets– Farm produce can be either eaten by the farmer or sold in the market. Usually, the farmers would have a certain level of consumption, hence they can easily plan for this. The greatest risk, however, is the market uncertainty. As cropping intensity increases, the produce would be increasing and therefore the amount available for the market would increase (Fig. 9). Any farming system therefore will succeed only if market can absorb the produce, otherwise prices will go down and the farmers will be losing.

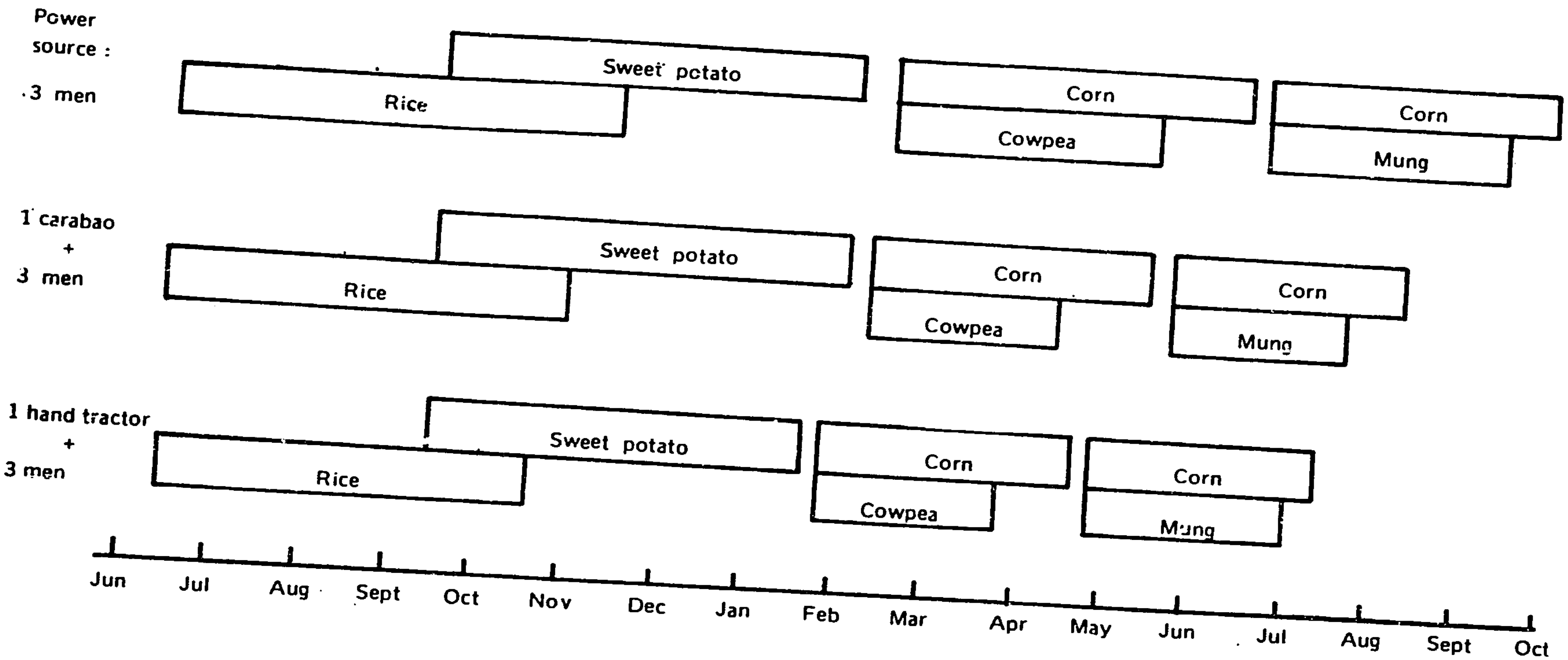


Fig. 8. Time requirement of a cropping pattern with three power sources.

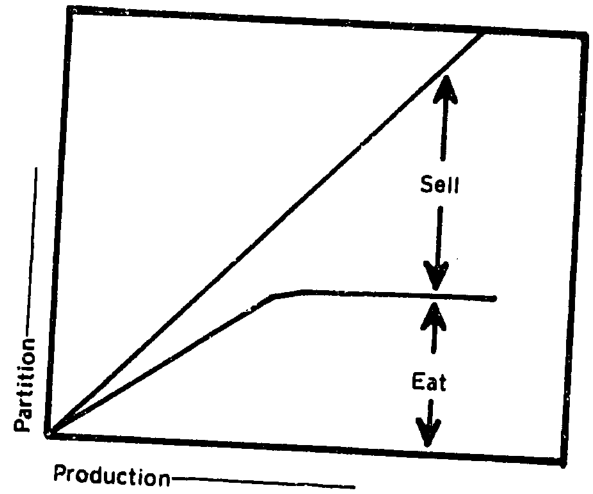


Fig. 9. Distribution of the produce in a 2-ha subsistence farm

CONCLUSION

In a cropping system, the amount of by-products can be as high or higher than the marketable produce (Table 3). This may go to waste if not utilized in an animal enterprise.

Finally, I would like to present an integrated farming system suggested by Dr. Bradfield. The area is 2.5 ha to be divided into different lots as shown in Fig. 10. The cropping calendar and area distribution and expected yields are shown in Table 4. The other resources required are not, however, presented.

Table 3. Digestible nutrient production from six irrigated cropping systems

System	Digestible protein		Non-protein digestible nutrient	
	Amount (kg/ha)	Marketable (%)	Amount (kg/ha)	Marketable (%)
A	920	29	14,900	39
B	670	64	6,600	47
C	1,260	40	11,800	38
D	720	29	6,700	32
E	810	63	17,000	24
F	770	61	10,200	37

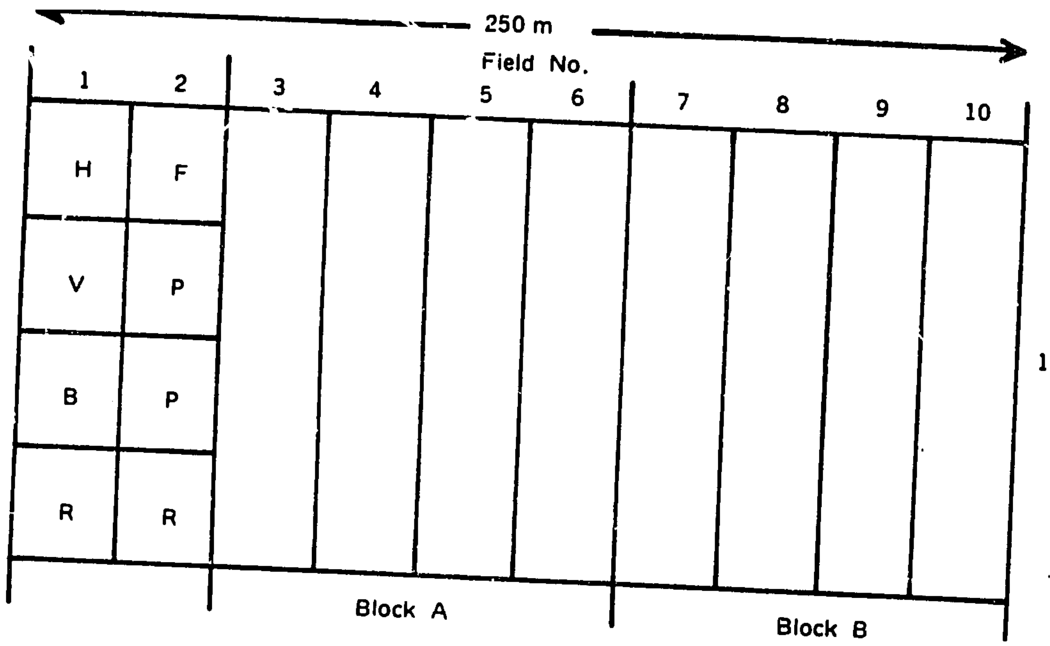


Fig. 10a. Layout for a 2.5-hectare multiple cropping farm (H = house lot, F = fruit garden, V = vegetable, B = barn, P = pasture, R = reservoir).

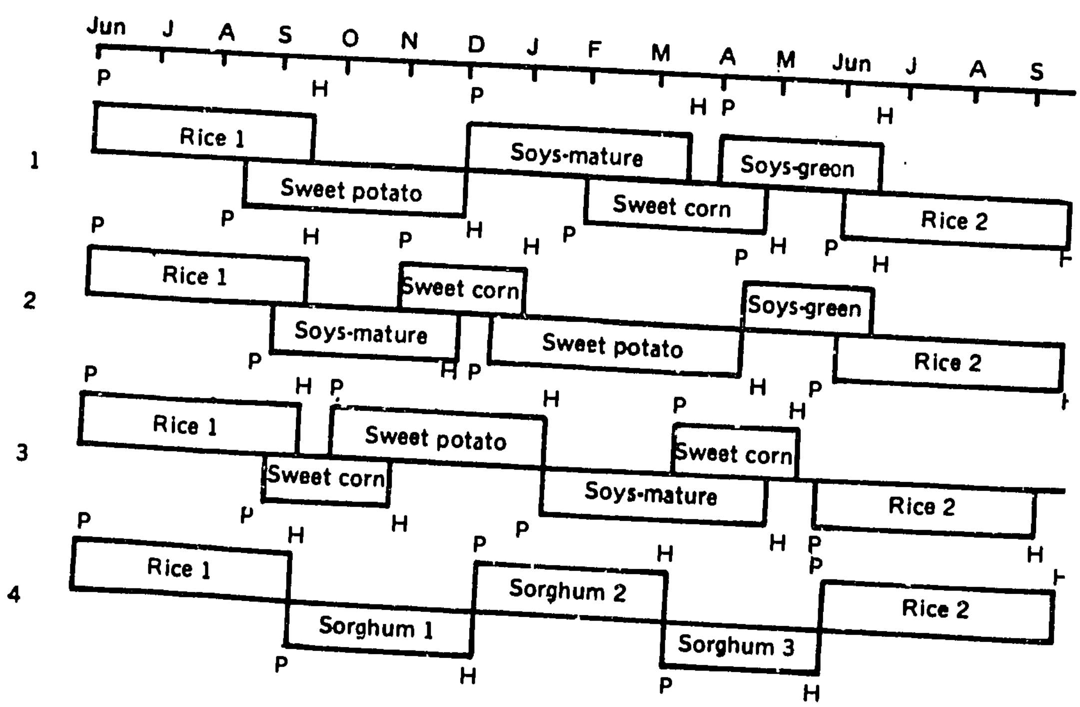


Fig. 10b. Annual sequence of crops on four fields showing intercropping.

Table 4. Estimated annual production from a well-managed 2.5-hectare irrigated farm in the tropics under intensive multiple cropping

Layout of farm	Area
Homesite with fruit trees	0.10 ha
Family vegetable garden	0.10 ha
Pasture	0.30 ha
For diversified crop rotations 8 x 1/4 ha fields	2.00 ha
Total	2.50 ha

ANNUAL CROP ROTATIONS

Rotation	June 1—Sept. 15	Sept. 16—Nov. 30	Dec. 1—Feb. 15	Feb. 16—Apr. 30	May 1—June 30
I	Rice	Sweet potato	Soybeans-M	Sweet corn	Soybeans-G.
II	Rice	Soybeans-G.	Sweet corn	Sweet potato	Early sweet corn
III	Rice	Sweet corn	Sweet potato	Soybeans-M	Cabbage
IV	Rice	Sorghum-1	Sorghum-2	Sorghum-3	—

SUMMARY BY CROPS

Crop	Fields (no./yr)	Area (ha/yr)	Yield (t/ha)	Total production
Rice	4 x 2 = 8	2.0	4.0	8.0
Sweet potato	3 x 2 = 6	1.5	20.0	30.0
Sweet corn	4 x 2 = 8	2.0	35,000 (ears)	70,000 (ears)
Sorghum	3 x 2 = 6	1.5	6.0	9.0
Soybeans-Gr.	2 x 2 = 4	1.0	6.0	6.0
Soybeans-M.	2 x 2 = 4	1.0	2.5	2.5
Cabbage	1 x 2 = 2	0.5	25.0	12.5
Total	38	9.5		

DEFINITIONS

Multiple cropping terminology has become extremely garbled. The following word usage adopted.

Multiple cropping– the growing of more than one crop on the same land in one year.

Mixed cropping– two or more crops grown simultaneously and intermingled; no row arrangem (Ruthenberg, 1971).

Intercropping– two or more crops grown simultaneously in alternate rows in the same ar (Ruthenberg, 1971).

Relay planting– the maturing annual crop interplanted with seedlings or seeds of the followi crop (Ruthenberg, 1971).

Cropping pattern– the yearly sequence and spatial arrangement of crops or of crops and fallo on a given area.

Cropping system– the cropping patterns utilized on a given farm and their interaction with fan resources and the available technology which determine their makeup.

REFERENCES

1. Banta, G. R. 1973. Comparison of power sources in multiple cropping. (IRRI Saturday Seminar).
2. Garrity, D. P. 1976. A test of potential cropping patterns for an upland rice-growing region of the Philippines. MS thesis.
3. Harwood, R. R. 1976. Factors affecting cropping systems.
4. ————. 1973. The concepts of multiple cropping. An introduction to the principle of cropping systems design.
5. IRRI, 1973. Annual Report for 1972. Los Banos, Laguna, Philippines.
6. IRRI, 1972. Rice, Science and Man. Los Banos, Laguna, Philippines.

DISCUSSION

Q. Did the study consider the amount of waste (corn stalk etc.) produced by the farmers?

A. About 50% of local produce will be by-products such as stover and straw.

Comment: In labor distribution in the farm, the amount of labor spent in the family such as household activities should also be included.

Comment: On lowland where there is water inflow and no outflow, fish raising can be tried. During monsoon, there is sufficient rainfall enough for the second crop period, which is most suitable for fish pond. In this case in Taiwan, the 1st crop is rice and the 2nd crop is normally fish. The fish are kept in the ditch in the paddy; the rice straw left over after the 1st crop of rice becomes fish food.

Comment: There is a need to pay more attention to the market as a component that can trigger or not trigger cropping system. An existing project encourages to solve some constraints at the beginning (early rainy season or tail-end of rainy season) by calling it constraints graphing (i.e., erratic rain at the beginning). This may avoid bringing products to the market all at the same time and within the same time span. More and more, we should address ourselves to the constraints graphing under the general umbrella of marketing cropping systems.

Comment: In Japan, cooperative use of labor is one strategy used by farmers to overcome constraint of labor (i.e., nursery beds)

Carandang: In some areas in the Philippines, relay cropping is used to get away from too much labor requirement; another is the use of simple implements.

INTEGRATED FARMING WITH FISH AS MAJOR ENTERPRISE

by

Catalino R. dela Cruz

INTRODUCTION

Integration of any two or three-commodities involving fish, crops and livestock has been practiced for centuries in limited scale. Numerous reports (Ref. 1 to 15) indicate the significant benefits that are derived in integrated systems in addition to increased production and availability of protein. The fish and livestock system provides solution to problems of animal waste management and pollution control. The availability of animal waste in site for fish production provides savings in fertilizer and feed costs including transport costs, and space utilization is maximized since dikes can be used for grazing of small ruminant animals such as goat, sheep, etc. or planted to vegetables, legumes and fruit trees. Dikes could also accommodate small housing units for pigs, chicken and ducks. On the other hand, pond water may be used by animals for drinking or body conditioning and cleaning the sheds. Fowls may also derive some of their food from the ponds.

Integration also increases the operational efficiency of the farm through better use of manpower and combined use of feed storage, processing and transport facilities.

While integrated system for crops and fish; livestock and fish; fowl and fish, or the combination of all may exist in limited scale, it is generally the case that fish is considered the secondary or minor product in most combination. It is perhaps appropriate to recognize a kind of integrated system where fish is considered as the major enterprise.

When is fish production considered as the major enterprise in an integrated system? A number of conditions would roughly justify fish as the major enterprise: 1) when fish contributes the greatest production or profit in the system; 2) when fishponds exist ahead of the commodities that are to be added and adopted into the system; 3) when the area is most suitable for fish production such as swamplands or floodplains, whereby conversion into fishponds would land itself into integration with other commodities due to the existence of dikes; 4) when the area occupied by fishponds is greater than the space occupied by other commodities of comparable importance; and 5) when conversion of some area such as ricefields is done in favor of fish where the area it would occupy is equal to or greater than the remaining portion.

It is estimated that about 425,000 ha of ponds and other aquaculture facilities exist in coastal areas of the South China Sea countries. The potential may be 2.5 million hectares or more[16]. In the Philippines, some 1.76,000 ha and 6,000 ha of brackish and freshwater fishponds, respectively, are on record. Added to these are 126,000 hectares of swamplands and 1.4 million hectares of irrigated ricefields which can be tapped for fish production. Where conditions warrant, addition of livestock, fowl, poultry and crops into the fishpond operation may be done.

Fish Integration with Agricultural Crops. The production of fish in ricefields has been practiced in Southeast Asia for centuries[1,12,6] with improvements and modifications being introduced at present[1]. The extent of the area covered by irrigated ricefields in some Asian countries is vast (Table 1). The leading countries that are taking advantage of the importance of this resource, as far as fish supply is concerned, are Indonesia, Thailand, Malaysia, Japan, India, Vietnam and Hongkong. Philippines is just beginning its rice-fish culture program.

Table 1. Estimates of the total area of irrigated ricefields and those with fish culture in some Asian countries[9]

Country	Total irrigated ricefields (hectares)	Area with rice-fish culture (hectares)	Source
Cambodia	1,400,000	—	Hora & Pillay, 1962
Hongkong	8,080,000	200	Hora & Pillay, 1962
India	5,762,792	1,619	
Indonesia	4,500,000	90,492 + 4,000,000*	Ardinawata, 1957
Japan	2,991,100	3,380	Hora & Pillay, 1962; Nambian, 1970
Malaysia	332,060	45,500	Hora & Pillay, 1962
Philippines	1,400,000	—	Mears *et al.*, 1974
Sri Lanka	350,000	—	Boonbrahm, 1972
Thailand	4,000,000	200,000	FAO
Vietnam	4,067,990	1,550	Hora & Pillay, 1962

* 90,492 hectares under cultural system and 4,000,000 hectares under captural system.

Two schemes of fish culture in paddy fields are practised– the combined fish and rice culture in one area and the rotational cropping of rice and fish. A number of more appropriate agricultural crops in either of these basic schemes have been introduced[6]. Terrestrial crops such as beans, onions, *Brassica* spp. sweet potato, etc. are grown in paddy dikes while aquatic crops such as kangkong (*Ipomoea aquatica*), taro (*Colocasia* spp.), etc. are grown in water.

The recommended species for this system is common carp (*Cyprinus carpio*) and tilapia species[1]. Production figures for these species in some countries under different systems and management input are given in Table 2.

In the above scheme of producing fish, the combined rice-fish culture together with other crops, consider crops as the major enterprise. The rotational cropping of rice and fish is the scheme that would fit to the considered criteria of having fish as a major enterprise. In a regular rice and fish rotation scheme, if an original riceland area is seeded with fish instead of rice, it is expected that the income from rice can be equaled or exceeded by the income from fish. Similarly, the conversion of a larger portion of a farm area into fish production units would show a shift of emphasis from agricultural crops to fish production. This was what happened when most of Taiwan's integrated fish farms were converted fron rice paddies into aquaculture production units[3].

Table 2. Productivity of fish culture in padi fields under the cultural system[9,1,4]

Country	Main fish species	Type of culture	Average yield, kg/ha
Indonesia	*C. carpio*	F	150/4—6 months
	C. carpio	RF	75—100/3—4 months
Japan	*C. carpio*	RF	100—200/year
	C. carpio	RF*	700—1100/year to 1100—1800/year
Thailand	*C. carpio*	F	80—160/3—6 months
	C. carpio	RF	10—20/3—4 months
	C. carpio	RF*	210—250/6 months
Vietnam	*C. carpio*	F/RF	50—130/10 months
Philippines	*Tilapia nilotica*	F	As high as 245/3 months
	Tilapia spp.	RF	100—200/3—4 months
	Tilapia nilotica	F*	500—690/4 months
	Tilapia spp. and *C. carpio*	RF	As high as 290/3—4 months

F — alternate culture of fish and rice
F* — alternate culture of fish and rice with supplementary feeding
RF — simultaneous culture of rice and fish
RF* — simultaneous culture of rice and fish with supplementary feeding

Analysis of the additional net profit obtainable from fish in combined rice-fish culture shows that it may vary from $60 to $90 per cropping under Philippine condition[4]. Cost and return analysis showed that income from rice with fish produced in an area originally planted with rice indicated promising results in favor of fish. Consideration of other benefits derived from rotational cropping of rice and fish will make the system more attractive to farmers.

Fish-animal Integration. Available information shows that most of the integrated farm under this category have fish as the major enterprise. The spaces utilized by the animals confined in pens were very small, varying from negligible to less than 10%. The sheds or pens, depending on the kind of animals may be constructed alongside of ponds or directly above the pondwater. The animals in the pen may also be put in one roof such as a chicken cage constructed above the pig space[7].

Tables 4 to 7 which were derived from the case studies presented during the ICLARM-SEARCA conference on integrated Agriculture-Aquaculture Farming Systems, show the cost and return figures from various types of integrated fish and animal farming. It can be seen that the production cost of animals in the systems are much higher than the fish.

With the exception of the fish-pig farm in India (Table 4) and the fish-duck combination in Hongkong, India, Indonesia and Nepal (Table 5), the other integrated systems have profit margin favoring the land-based animal component. However, to realize these profits, high investment is necessary.

Although the profit from fish is lower in most of the systems, the benefit-cost ratios have largely favored it. In all cases studied, the management input for fish production component is minimal, with only cost of fry and labor comprising production cost. The low production cost is attributable to the animal manure that provided fertilizer or feed to the fishes. Unfortunatley, all case studies did not quantify the amount of animal manure that went into the system and its equivalent money value.

The importance of animal manure in increasing fish yield has long been known in China. It was reported that the manure produced by 20–30 pigs in a year could produce the same results as one ton of ammonium sulfate applied to the soil[7]. Pig-fish farming is, therefore, widely practiced in China, not only to produce their meat requirement but also to supply manure to the pond. Table 3 shows the high production of fish obtained in manured ponds.

Compared with fish-crop integration, the yield and income derived from fish-livestock-fowl combination is much higher. Fish production combined with animal production averaged 6.22 tons per hectare/year, compared to crops which is 1.31[7].

Fish-animal-crops Integration. This kind of integration is merely putting the three commodities together. When fish is the major enterprise, it would mean putting them separately adjacent to each other in one farm unit or the animal may just use a space above the pond water while the plants are grown on top of dikes and slope of ditches. Roughly the area occupied by dikes and ditches in a pond system is as much as 20% of total area.

The management techniques for these combination need modification in order to adjust to the requirements of the new addition (crops and livestock) to the system. As an example: in the case of fish-pig-vegetables combination with the latter two as additions, the number of pigs must be able to supply adequately the manure requirements of the fish and vegetables. Another alternative in the management, however, is for the vegetables to exist independently and just occupy the space available in the fishpond dikes. Further still, the vegetables aside from being a human food, may also be fed to pigs and fish. A second example is the fish-goat-vegetables combination. In this combination, goat would serve as biological control for grasses growing on dikes. With the addition of vegetable for human food the grazing area of goat will be reduced, hence its number will correspondingly decrease to match the availability of grasses.

With the above examples the three-commodity system, just like the two-commodity system, needs proper balance to be efficient. Even the design of the fishponds and water system need modifications in order to make it function in truly integrated way.

PROSPECTS, NEEDS AND PROBLEMS

The vast developed irrigated ricelands, existing fishponds and swamplands offer great potential to which integration of fish-rice and livestock-fish may be done without requiring much additional space.

Use of pesticides threaten the combined culture of rice and fish. This problem causes a decline in fish production from paddies in some Asian countries. Tan and Khoo[9] reported that Indonesia, the country which has the largest area devoted to rice-fish production, uses two million kg of insecticides which are applied to more than one million hectares of ricefields annually. Although some advances had been achieved on selecting the kind of chemical to use and its proper application in rice-fish culture[1] the risk is still present when practiced in wide scale because of the danger of pesticide contamination from adjacent areas which do not practice it.

Table 3. Production data in different types of fish-animal integration in some countries

Country	Type of integ./area	Production/period	Source
Hongkong	Fish-duck/ha	2,750—5,640 kg/ha fish; ducks stocked at 2,500 to 3,500/ha/yr yielding 5—6 tons/ha duck meat	Delmendo, 1979
Hongkong	Fish-duck/ha	3,472 kg fish stocked from 1,250—12,090 with duck stocked at 500—2,000, yielding 7,389 kg	Sin, 1979
Hungary	Fish-duck/ha	500—800 kg/ha carps in 150 days with 300 to 500 ducks	Woynarovich, 1976
India	Fish-pig/ha	7,300 kg/ha/yr fish stocked at 8,500/ha with 130 pigs yielding 1,096 kg	Jhingran and Sharma, 1979
India	Fish-duck/ha	4,232 kg/ha/yr fish stocked at 6,340/ha with 100 ducks yielding 250 kg meat and 1,835 eggs	Jhingran and Sharma, 1979
Taiwan	Fish-pig/ha	7,371 kg fish stocked at 35,500/ha with 210 pigs	Chen, 1979
Thailand	Fish-pig-poultry/ 0.25 ha	4,000 kg *Pangasius* spp. 8,000 kg pig and 15,330 chicken eggs	Delmendo, 1979
Thailand	Fish-pig/ha	2,000—5,000 kg/ha/6 mos., tilapia stocked at 25,000 to 30,000/ha; pig stocked at 60/ha	Delmendo, 1979
Vietnam	Fish-duck/ha	5,000 kg/ha/yr fish with ducks at 1,000—2,000/ha	Delmendo, 1979

Table 4. One-year economics of fish-pig farming[8,9,3,7]

Country	Actual area (ha)	Stocking density No. /ha		Profit per ha		
		Fish	Pig	Fish	Pig	Total
India (Rs8=$1)	0.1	8,500	130	$5,878.75	$1,282.50	$7,161.25
Malaysia (M$2.2=$1)	8	788	38	5,159.10	6,909.10	12,068.19
Taiwan (NT$36=$1)	1.0	35,500	210	7,674.75	14,058.33	21,733.08
Thailand (20 Baht=$1)	0.64	23,438	70	1,445.31	3,956.17	5,401.48
Thailand	0.96	26,042	104	914.06	3,842.71	4,756.77
Thailand	1.60	125,000	63	625.00	1,046.88	1,671.88

Table 4a. Ratio of profit to production cost

Country	Area (ha)	Production cost/kg		Profit/kg		Profit/prod. cost	
		Fish	Pig	Fish	Pig	Fish	Pig
India	0.1	$0.10	$0.50	$0.80	$0.12	$8.00	$0.24
Malaysia	8.0	0.15	0.63	0.47	0.15	3.13	0.24
Taiwan	1.0	—	0.92	1.04	—	—	—
Thailand	0.6	0.03	0.43	0.37	0.47	12.33	1.09
Thailand	0.96	0.12	0.59	0.28	0.34	2.33	0.57
Thailand	1.6	0.10	0.81	0.20	0.14	2.00	0.17

With the setback on combined rice-fish culture against uncontrolled use of pesticide the p of adopting rotational cropping of rice and fish will become more and more important in augr the supply of protein. This system offers a number of advantages as reported by dela Cruz[4]. Th

1. Reduced chance of pesticide accumulation in fish tissues since rice and fish are gr separate areas or in different time. Presumably by the time rice is harvested, the pesticide has degraded and subsequently fish stocked is safeguarded.

2. Better pest control since the life cycle of insect pests is disrupted.

3. Mutually beneficial interaction between fish and rice crops. Fertilizer residues fr paddies can be used subsequently by rice. On the other hand, decomposing rice stubbles dui culture serves as medium for growth of natural food. The decomposed stubbles also add fertilit soil for the next crop.

4. Decreased rice production cost, because of the possibility of zero tillage. After fish tion, the paddy bottom can be directly planted to rice. Some weeds or algae may grow wh require single harrowing only.

5. Lower construction cost of fish paddy as compared to regular fishpond with deepe higher and larger dikes.

This system necessitates the cyclic conversion of prescribed paddy fields in a farm unit paddies. This means that overall production of rice would decrease as a result of the withdrawal area converted to fish production. This scheme is suitable in irrigated areas and in countries t monsoons or those located within the typhoon belt. While rotational cropping in adjacent one method, fish production in paddies may also be done during the rainy months instead of ri is usually faced with great climatic risk. Rice production follows during the dry months wher is already over. This scheme is also suitable for countries with rice surplus and marketing p

In the case of integrating livestock production with fish, most of the case studies showed i income from the livestock, although the investment required was high. However, two cases (' 5a and 6) incurred losses. This situation demonstrates some implications:

1. Among the cases studied, there was a wide range in the stocking density of animals ir to the area of fishpond being supplied with manure. The same is also true with the stocking d fish. Clearly, the optimum relationship between fish and animals are not established yet. It is to establish the balanced relationship between the number of fish and animal in order to hav cient integrated system. Allocating more inputs or less in either component of the system v the cost and return pattern.

2. Proper strain of animals that are to be included in the system should be selected.

3. It also implies that as more commodities is dealt with, the management system more complicated. There must be know-how in the production aspect of various compone system. Unfortunately, majority of the farmers are knowledgeable only in producing on crop. They need to be provided with training on the kind of integration they wish to venture ir

It is worth to note that all information used in this paper were obtained in systems l freshwater areas. This is understandable owing to the fact that plants and animals require and dependable supply of freshwater. Thus, in brackishwater fishponds, integrated systen practised if freshwater is assured. The integration of animals with fish may also be hindered in areas where transportation problem exists. There are conditions where transport of fish product is done by using small boats.

Table 5. One year economics of fish-duck farming[11,8,6,10,3]

Country	Pond area (ha)	Stocking density No./ha		Profit/ha, ($)		
		Fish	Duck	Fish	Duck	Total
Hongkong (HK$5=$1)	1.00	1,250—12,090	500—2,000	1,980	1,915	3,895
India (Rs8=$1)	1.48	6,340	100	2,013	−41	1,972
Indonesia (West Java) (Rs 312=$1)	0.2625	—	—	948	753	1,701
Nepal (Rs11.9=$1)	0.25	3,200	400	971	276	1,247
Taiwan	1.00	10,852	3,200 Mule	4.140	7,111	11,251
(NT$[illegible]=$1)	1.00	10,852	1,500 egg-laying	4,140	2,520	6,660

Table 5a. Ratio of profit to production cost (based on actual area)

Country	Pond area (ha)	Prod. cost ($)		Profit ($)		Profit/prod	
		Fish	Duck	Fish	Duck	Fish	Duck
Hongkong	1.0	4,103	10,277	1,980	1,915	0.48	0.19
India	1.48	1,419	465	2,979	−60	2.10	− 0.13
Indonesia (West Java)	0.2625	958	940	948	755	0.99	0.80
Nepal	0.25	376	162	243	48	0.65	0.30
Taiwan	1.0	1,666.39	—	4,140.28	—	2.48	—
	1.0	—	—	—	—	—	—

Table 6. Annual economics of a fish, pig, chicken and duck farming in 4-ha disused mining pool at Taiping, Perak Malaysia[1 2]

Items		Value ($) (M$2.2=$1)
A. Operating costs		
1. Fish production — Cost of fry		375.00
2. Pig production — Feed, labor and maintenance		10,636.36
3. Chicken production — Cost of 18,000 chicks, feed, labor and maintenance		25,909.09
4. Duck production — Cost of 1,000 ducklings, feed, labor and maintenance		2,095.45
	Total	39,015.90
B. Gross income		
1. Sale of bighead carps		3,863.64
2. Sale of 96 pigs		8,290.91
3. Sale of 17,100 chickens		34,977.27
4. Sale of 800 ducks		1,636.36
	Total	48,768.18
C. Profit = B − A		
1. Fish production		3,488.64
2. Pig production		−2,345.45
3. Chicken production		9,068.18
4. Duck production		− 459.09
	Total	2,775.00
D. Profit/operating cost = C/A		
1. Fish		9.3
2. Pig		−0.22
3. Chicken		0.35
4. Duck		−0.22

Table 7. One-year economics of fish-chicken farming[6,7]

Country	Pond area (ha)	Stocking density		Prod. cost ($)		Profit ($)		Profit/prod.	
		Fish	Chicken	Fish	Chicken	Fish	Chicken	Fish	Chicken
Indonesia (West Java)	0.1203	—	—	816	3,948	1,259	2,041	1.54	0.52
Indonesia (West Java)	0.1000	—	1/10 m^2	365	1,301	436	813	1.19	0.62

Table 7a. One-year economics of fish-geese farming[11]

Country	Pond area (ha)	Stocking density		Prod. cost ($)		Profit ($)		Profit/prod.	
		Fish	Geese	Fish	Geese	Fish	Geese	Fish	Geese
Hongkong	1.0	1,110–4,630	1,500–2,500	4,265	23,701	1,822	3,494	0.43	0.15

Table 7b. One-year economics of fish-sheep farming[6]

Country	Pond area (ha)	Stocking density		Prod. cost ($)		Profit ($)		Profit/prod.	
		Fish	Sheep	Fish	Sheep	Fish	Sheep	Fish	Sheep
Indonesia (West Java)	0.0084	—	—	313	505	72	255	0.23	0.50

Another aspect in fish-animal integration wherein little work is being done is its possible hazard to public health. While no case of disease that may have been transmitted to humans through the fish-animal system has been reported, research on this area must be done to ascertain safety of the general public.

CONCLUSION

For a more efficient and productive integrated farming, the following are suggested:

1. To pilot-test selected and profitable integrated systems existing in some countries to other places where such may apply.

2. To collate existing information and management techniques in progressive integrated system to come up with a technology package that could be verified or pilot-tested.

3. To formulate and conduct short training courses in various types of integrated systems for those who will participate in the pilot testing including farmers as well.

4. To conduct an in-depth research in order to generate an optimized and efficient system for various combinations of commodities.

5. To conduct research on the impact of insecticides use at the farm level and evaluate the magnitude of the problem.

6. To ensure adequate supply of fingerlings and selected breeds of animals through establishment of hatcheries and animal distribution centers.

REFERENCES

1. Arce, R. G. and C. R. dela Cruz. 1978. Improved Rice-Fish Culture in the Philippines. Int. Comm. on Irrig. and Drainage (ICID) 2nd Regional Afro-Asian Conference. Tech. Pap. Manila, Philippines. pp. 136–145.
2. CLSU Model Farm. Annual Report 1978–1979. CLSU, Nueva Ecija. 11 p.
3. Chen, T. P. 1979. Country Report and Case Studies. Integrated Agriculture-Aquaculture Farming in Taiwan. ICLARM-SEARCA Conf. on Integ. Agri-Aquaculture Farming Systems. Manila, Philippines. 8 p.
4. Cruz, C. R. dela. 1979. Country Reports and Case Studies: Integrated Agriculture-Aquaculture Farming Systems in the Philippines. ICLARM-SEARCA Conf. on Integ. Agri-Aquaculture Farming Systems. Manila, Philippines. 30 p.
5. Cruz, Emmanuel. 1979. Country Report and Case Studies: Preliminary Results of Integrated Pig-Fish and Duck-Fish Production Test. ICLARM-SEARCA Conf. on Integrated Agri-Aquaculture Farming Systems. Manila, Philippines 15 p.
6. Djajadiredja, R. *et al.* 1979. Freshwater Aquaculture in Indonesia with Special Reference to Small Agriculture/Aquaculture Integration Farming Systems in West Java. ICLARM-SEARCA Conf. on Integ. Agri-Aquaculture Farming Systems. Manila, Philippines. 58 p.
7. Delmendo, M. 1979. A Review of Integrated Livestock-Fowl-Fish Farming Systems. ICLARM-SEARCA Conf. on Integrated Agri-Aquaculture Farming Systems. Manila, Philippines. 40 p.
8. Jhingran, V. G. and B. K. Sharma. 1979. Fish-Cum-Livestock Farming in India. Central Inland Fisheries Research Inst. Barrackpore, India, 25 p.
9. Khoo, K. H. and Eddy S. P. Tan. 1979. Review of Rice-Fish Culture in S.E. Asia. ICLARM-SEARCA Conf. on Integ. Agri-Aquaculture Farming Systems. Manila, Philippines. 30 p.
10. Rajbanshi, K. G. 1979. A Case Study of the Economics of Integrated Farming Systems-Agriculture, Aquaculture and Animal Husbandry in Nepal. ICLARM-SEARCA Conf. on Integ. Agri-Aquaculture Farming Systems. Manila, Philippines. 23 p.
11. Sin, Alfred W. 1979. Country Report and Case Studies: Integrated Fish-Animal Husbandry Systems in Hongkong and Case Studies in Fish-Cum-Duck and Fish-Cum Geese Systems. ICLARM-SEARCA Conf. on Integ. Agri-Aquaculture Farming Systems. Manila, Philippines. 33 p.
12. Tan, E. S. P. and K. H. Khoo. 1979. The integration of Fish-Farming with Agriculture in Malaysia. ICLARM-SEARCA Conf. on Integ. Agri-Aquaculture Farming Systems. Manila, Philippines. 32 p.
13. Woynarovich, E. 1976. The Feasibility of Combining Animal Husbandry with Fish Farming, with Special Reference to Duck and Pig Production. FAO Tech. Conf. in Aquaculture, Kyoto, Japan. FIR: AQ/Conf./76/R. 6. 10 p.
14. ————. 1979. Country Reports and Case Studies: Raising Ducks on Fishponds (Fish-cum-Duck-Culture). ICLARM-SEARCA Conf. on Integ. Agri-Aquaculture Farming Systems. Manila, Philippines. 20 p.
15. ————. 1979. Country Reports and Case Studies: Utilization of Piggery Wastes in Fishponds. ICLARM-SEARCA Conf. on Integ. Agri-Aquaculture Farming Systems. Manila, Philippines.
16. South China Sea Fisheries Development and Coordinating Program (SCSFDCP). 1973. The South China Sea Fisheries– a proposal for accelerated development. UNDP/FAO, SCS/DEV/73/1. 136 p.

INTEGRATED FARMING WITH LIVESTOCK AS MAJOR ENTERPRISE: A CASE STUDY OF THE MAILIAO PROJECT IN TAIWAN

by

Huang Chia

INTRODUCTION

Mailiao is a seashore town on the west coast of Taiwan facing Taiwan Strait. During winter months, continuous strong wind scorches every green leaf with the salts and fine sand. How this poor village of saline sandy soil land changed into a productive rural area is described in the following sections.

Haifung Village

Haifung is a small village in Mailiao township. This village with 38 families, had one very rich family, nine were very poor, the rest were below average.

The cultivated land of Haifung was reclaimed tidal land formed with alluvial sand of the Silo River. The Silo river's wide river bed is dry during winter. The northeastern seasonal wind during winter months blows up and accumulates fine sand dust to the south bank of Mailiao. Haifung village has an area of 150 hectares but 100 ha are owned by the rich farmer Mr. Lu, who increased his farm size by acquiring land mortgaged to him by his neighbors and which were not paid on time. In 1970, nine families in that village gave up their land to Mr. Lu. and worked for him as farm laborers.

The main crops are paddy rice and sweet potatoes. Farmers also raise one crop of watermelon from March to June. If summer rainfall comes too early, it will destroy the growing watermelon completely; if weather is favorable they will have an excellent crop. Watermelon raising is called '90 days gamble.' The writer saw farmers wept in the field over rotten melon, destroyed by heavy rainfall.

THE FORMATION OF MAILIAO PROJECT

In 1970, Dr. J.T. Yu, then chief of the Animal Industry Division of the Joint Commission on Rural Reconstruction (JCRR) visited Haifung village, and saw the abject poverty in the village. After that visit, Dr. Yu asked the writer to propose a project to assist these poor farmers by means of raising pigs and to increase soil fertility with pig manure. Dr. Yu proposed land reconsolidation in that area to improve transportation of feeds and pigs, and also to make pig manure application more convenient.

The writer, together with Mr. C.P. Wanq from Taiwan Provincial Department of Agriculture and Forestry (PDAF), and Mr. H.S. Lee from the local county (Hsien) government, visited the Mailiao Farmers Association in order to identify the area's social condition and natural resources. They found that the Mailiao Farmers Association (FA) was almost bankrupt. With 5,000 members, the savings deposit of the FA was below 3 million Taiwan dollars (US$750,000), less than one tenth of a normal township FA's deposit. The manager was suspended from duty due to court action. An interview with the farmers in Haifung village was met with suspicious eyes because previous assistance from the government was taken advantaged of by the rich farmer Mr. Lu.

After three months, the 3-man team finally succeeded in getting the cooperation of both the rich (Mr. Lu) and the poor farmers, largely due to the assistance of a local farmer Mr. H.S. Wang, a natural leader in that area.

Since March 1971, 100 hectares of land had been reconsolidated with a main road at the middle. There were nine hectares bought from the landlord Lu with bank loan to the nine landless-farmers. The land was sold by Mr. Lu at very reasonable price of NT$60,000 (1US$=NT$38) per hectare (now a hectare is worth NT$600,000). The original project (Integrated Livestock-Crop-Fish Farming at Mailiao) design for the development of 100 hectares and 37 farms was financed by a grant of NT$1,691,000 from JCRR, Taiwan Provincial Department of Agriculture and Forestry (PDAF) and Yunlin Hsien government and a total loan of NT$5,915,000 (Appendix 1).

SOCIAL AND ECONOMIC STATUS

Supported by the project, Prof. C.Y. Wu and Miss C.S. Huang of the Agricultural Economics Department, National Taiwan University, conducted a survey in 1971 on the rural economic situation of the 37 families. Their findings were as follows:

1. *Land ownership*

Before the project was established, the ownership of the 37 farmers were:

Farm acreage (ha)	Families
0	9
0 – 0.50	5
0.51 – 1.00	8
1.01 – 1.50	5
1.51 – 5.00	5
5.01 –	5

2. *Family population*

Farm size no. persons	Below 0.50 ha	0.51–1.00	1.01–1.50	1.51–5.00	5.01–
Farming force	1.2	1.8	1.8	2.7	3.2
For hire	0.2	0.4	0.8	0.2	0
Household	0.6	0.5	1.0	0.6	0.6
Student	1.0	0.7	1.6	0.7	1.7
Others	2.4	2.6	2.0	1.7	3.8
Out of village	0.4	0.4	0.8	0.15	0
Total	6.0	6.4	8.0	5.3	10.0

The average man-equivalent was 1.52 per family. It needs a one-hectare farm to fully employ one man's labor force, so in this project, one hectare was bought for the nine families without farm.

3. *Farm income in 1970 in Haifung village (NT$/ha)*

Expenditures	Paddy rice	Sweet potato	Peanuts.	Sugarcane	Watermelon
Seeds/planting materials	385	648	1,123	1,445	297
Chemical fertilizer	3,565	1,507	673	4,025	2,753
Compost	337	201	434	253	61
Chemicals	2,126	141	335	160	1,805
Others	178	20	56	–	58
Labor	4,047	1,203	3,118	6,412	1,241
Draft animal	574	732	326	1,474	87
Tillers	356	689	1,227	780	2,528
Total cost	11,567	5,141	7,292	-14,549	8,830
Self-supply	1,661	1,261	2,225	2,027	174
Cash payment	9,907	3,880	5,067	12,522	8,636
Production (kg)	4,079	12,411	1,127	44,840	22,012
Value (NT$)	15,540	6,671	8,412	-22,419	13,116
Profit					
Incl. self-supply	3,972	-1,530	1,120	7,870	4,286
Excl. self-supply	5,633	2,791	3,345	9,897	4,460
US$	141	70	84	247	112

The usual rotation systems of the one hectare-farm and income from each were:

Paddy rice and sweet potato	US$ 211
Peanuts and watermelon	196
Sugarcane (18 months) and rice	389 for 2 years

In 1970, the average family income was NT$45,720 (US$1,203) year in Taiwan: in the rural area the average annual income was NT$35,439 (US$932) of which the income from farming was NT$17,257 (US$454). Therefore the farm income in Haifung was only half of the average in Taiwan.

4. *Family income and expenditure*

The farming families in the village earned additional income by working as coolies (boys) and in textile factories (girls). But those with farms larger than five hectares did not have surplus labor.

Family income in Haifung, 1970 (NT$)

Farm acreage (ha)	Below 0.5	0.51–1.00	1.01–1.50	1.51–2.00	2.01–5.00	5.01–
Total income	11,354	7,346	14,357	38,647	47,596	78,406
from crop	2,174	2,696	4,387	35,847	47,071	74,906
from pigs	–	–	1,160	–	–	3,500
off-farm	9,180	4,650	8,810	2,800	525	–

Family expenditures in Haifung, 1970 (NT$)

Farm acreage (ha)	Below 0.5	0.51–1.00	1.01–1.50	1.51–2.00	2.01–5.00	5.01–
Food						
Rice	3,325	5,003	6,307	8,160	4,945	16,804
Sweet potato	396	816	250	833	425	1,360
Supplementary	1,520	2,264	2,740	2,700	4,800	3,733
Education	134	409	1,280	383	100	5,567
Clothing	1,500	1,237	1,720	1,000	900	4,167
Medical	3,100	1,037	1,100	333	2,300	2,133
Tobacco, wine	1,002	378	852	1,800	–	669
Electricity	326	377	204	404	245	586
Worship (religion)	200	175	200	667	250	666
Transportation	40	125	40	167	400	–
Miscellaneous	60	113	68	67	300	2,200
Total	11,603	11,934	14,761	15,914	14,665	37,885

The 1970 balance sheet of the 37 families in Haifung (NT$)

Of the 37 families surveyed, 17 families were in debt; the rest had a net surplus ranging from NT$1,000 to more than NT$5,000.

	–10,000 or more	–10,000 to – 5,000	–5,000 to –1,000	–1,000 0	0 to 1,000	1,000 to 5,000	Above 5,000
No. of families	4	8	2	3	5	5	9
Average	–14,251	–9,635	–4,677	–661	541	2,812	16,936

Due to frequent natural hazards such as typhoons, high tide, and flood in that area, the average accumulated debt of the Haifung families was NT$51,916. The loan they borrowed from private lenders had higher interest of $25.55 per $100 a year. For those who could not pay on time, the over-due interest was added to the principal loan. Very soon the mortgaged land would be lost to the creditor. This was how Mr. Lu increased his land to 100 hectares from nine families in the village.

THE PROJECT

The project went through a preparation period of three months from the end of 1970. A project proposal was submitted to JCRR in March 1971 and approved in the same month. Land procurement for the nine landless families and land reconsolidation was implemented in June 1971.

The pigsties were constructed from a standard blueprint at a size of 140 m^2, for six breeding sows and 50 fattening pigs, with two partitions: one for feed storage and one for bedroom of the keeper. The pigsties were made of bricks and tile roof.

Each family raised five breeding gilts which were bought from the Provincial Livestock Research Institute. To start with, each farm also bought 50 piglets for fattening purpose. The first shipment of a truck-load of finished pigs were sold on November 15 of the same year.

The price of feeds and hogs in 1971 and 1972 was rather steady. The finished pig sold at NT$2, per 100 kg and feeds at about NT$5.00 per kg. Hog raisers had a net profit of about NT$350 for e pig marketed. The farmers could sell 100 fattened pigs a year to have a profit of NT$32,000, at equivalent of US$800 a year. This income status was considered fairly good then. The participat farmers were able to gradually repay the loan they borrowed from private creditors. Even the poor widow Lin, had afforded to buy a TV set for her children.

Since the latter part of 1972 through 1973, bad weather and the oil crisis around the wo raised prices of feed grains; hog feeds increased by 50% (NT$7.50 per kilo) while hog prices remain the same. The farmers were losing until August 1974. From August 1974 hog prices fluctuated frc NT$4,500 to NT$5,300 per 100 kg while the price of hog feeds remained at less than NT$8.90 per k With these prices of feeds and hog, Haifung farmers were able to have a net profit of NT$1,000 f each fattened pig sold. However, this boom in pig raising did not last long. A very serious depressic started in May 1979. This time the farmers suffered more than the 1972–1973 depression; a wean ling cost NT$100 and a fattened 90-kg pig sells for only NT$2,000 while the feed price increased t NT$9.40/kg. The Haifung farmers and all the pig raisers in Taiwan have, since then, been in a ver serious situation.

An over-all evaluation of the Mailiao-Haifung project would show the project's success. Th investment input was:

Grant: NT$1,691,000 (US$42,275)
Loan: NT$5,915,000 (US$147,875)
Total: NT$7,606,000 (US$190,150)
Per family farm: NT$205,568 (US$5,139.20)

Up to September 30, 1979, 82% of the loan has been repaid. From November 1971 to date, 36,500 fattened pigs were sold at a total profit of over 15 million NT$ (US$365,000). In eight years, each family earned US$10,000 on pig raising alone.

There were 12 hectares of fish ponds formed after the earth was moved for sea dike construction. The major fish raised is tilapia, fed with pig waste, and no other feed was given. The major expense was on electricity for pumping water (NT$7,000 per ha/year). The annual net income from fish pond was NT$35,000 per hectare. The highest income from fish pond was obtained from fresh water clam (Corbicula) which may yield a net profit of NT$300,000 per hectare/year, with a production cost of NT$10,000 for seedling and NT$30,000 for pumping water. The 10-ha tilapia pond and the two-hectare clam pond, gave the Haifung villagers an extra income of NT$1,300,000 a year.

The application of pig manure improved soil fertility of the crop land, but income from crops is still not quite reliable because of weather and unstable price. However, the 9 hectares of land that the 9 farmers bought with a loan of NT$60,000 per hectare is now worth 10 times the original price; [illegible]ation in the past 8 years was only two times. The land price increment was not only due to soil improvement, but also due to the area development on road system, electricity and irrigation. A tree (Casuarina) wind break belt established by the Forestry Bureau in 1972 was also very successful in lessening the wind damage during winter months.

LESSONS FROM EXPERIENCE

After the successful implementation of the Mailiao-Haifung project by the end of 1971, the government used this model for other villages. At the end of June 1979, there were 132 pig raising areas established in 67 townships in Taiwan, composed of 5,280 farm families. There are a few project areas as successful as Haifung, however, at least 20% of the project areas did not function as well.

A rural development project like the Haifung project should include social improvement as well as agricultural development. Therefore the project manager should be a social worker with a working knowledge on general farming practices.

Government funds, in grant and in loan, are necessary to start such a project, but the determination of the participating farmers are equally important. A too generous grant-in-aid may spoil the farmers. The extension agents should inform the farmers of all possible pitfalls as well as success from the project and should not paint too rosy a picture to lure the farmers.

Appendix I

Project title: Integrated Livestock-Crop-Fish Farming at Mailiao
Field 71-A21-J-677

Duration: January 1971 to December 1971

Budget:

Grant: JCRR: NT$1,091,000
Taiwan PDAF: NT$300,000
Yunlin Hsien Gov't.: NT$300,000
Total: NT$1,691,000

Loan: NT$5,915,000

Items and description:

A. Grant

1.	Survey and mapping	100 hectares	NT$ 30,000
2.	Earth work	For an earth dike and fish ponds with bulldozers moving 216,190 m^3 of earth	432,380
3.	Culverts and automatic tidal gates	Drainage gates 2 sets	
4.	Subsidy of material for manure storage and methane gas generators	For underground manure storage and methane generator pits construction material: cement 2,550 bags, steel 15 tons	250,400
5.	Methane gas pits steel plate covers	NT$2,100 each for 37 farms.	84,000
6.	Partial subsidy of power line establishment	About 60% subsidy	60,000
7.	Partial subsidy of deep wells	5 deep wells, about 12 m. deep, with 6-inch tubes	75,000
8.	Pumps and motors for liquid manure application	1 hp motor and pump	26,000
9.	Tractor and implements	Tractor and disc plow, disc harrow and rotavator	319,000
10.	Partial subsidy on breeding gilts	5 breeding gilts to each farm	76,500
11.	A cattleyard	For beef cattle	47,000
12.	Farmers education classes	On hog raising and animal health	14,500
13.	Supervising travel and per diem	For Tainan DAIS, Loukon Fishery Station, etc.	49,000
14.	Social and economic survey	NTU Agri. Econ. Dept.	94,000
15.	Contingency		28,220
	Total Grant		NT$1,691,000

B. Loan

1.	Long term loan for land procurement, pig barns construction, power line establishment and deep wells.	NT$1,650,000 10 years, 6% per annum
2.	Procurement of piglets	NT$1,015,000 5 years, 10%
3.	Revolving fund for feeds	NT$2,250,000 5 years, 10%
4.	Beef cattle loan	NT$1,000,000 10 years, 6% per annum
	Total Loan	NT$5,915,000

There was a one year grace period for the repayment of principal and interest.

DISCUSSION

Q. The Cagayan Valley in the Philippines has been classified as unstable production area – d... dry months there is drought; during wet months, there is maximum concentration of typho... This is a vast lowland area and if we raise pigs, we probably cannot market that. Would ... suggest any other livestock that will be good to raise there?

A. Filipino scientists are very much concerned with cost, income and market, which means tha... you cannot market pigs, for example, then you don't raise pigs. I feel that pigs would still ... reliable.

Q. In the Philippines, we have the land reform program. In these areas, land is subdivided to seve... farmers. Unofficially though, after farmers get the land, it is slowly recovered by the own... because he cannot provide inputs. Is this happening in Taiwan?

A. Land consolidation in Taiwan only means re-arrangement and consolidation of 3 or 5 pieces ... land belonging to one farmer. This does not have anything to do with land transfer. This is do... to be able to provide for roads.

Q. What is your purpose in building houses for pigs and family together?

A. The pig pen is better than their old houses; also, a caretaker needs to watch the pigs especia... during farrowing.

Q. Is the low price of pigs in Taiwan only temporary; what is the repurcussion of this situation ... Taiwan farmers in the future?

A. This is a temporary one – due to overproduction, which is also being experienced in other cou... tries like Korea. This year, we have a project on integration farming and farmers still like to jo... this project because they believe that this low-period will be over by next year.

Q. How is your government support (i.e., extension workers) in the case of expansion of the projec...

A. Until now, the government still supports the Mailiao project.

Q. Your table shows that the cost of investmen per family amounts to more than US$5,000. Do yo... think this amount can be done on a national scale?

A. Government cannot support if it is done at one time. Thus, it is done gradually where 700 ... more are provided loans at a time. Our subsidy goes to methane gas production and buying ... breeding stocks. A lot of government funds goes to building public facilities like electric lin... irrigation, roads – in this we use grants.

Comment: I don't agree that marketing is more important than production.

A. This is true. But if the middleman makes too much profit, then this will discourage the produce...

Comment: Maybe we should say that production is no problem; but we have to have a systemat... marketing scheme.

Q. What happened to the cattle component of the program which is mentioned in the project pro... posal?

A. We provided loan to buy cattle but repayment of the loan has not been good. Also, the price o... beef in Taiwan went down because the government allowed the importation of Australian bee...

245

THE PHILIPPINE EXPERIENCE IN INTEGRATED CROP-LIVESTOCK-FISH FARMING SYSTEMS

by

Elvira O. Tan

INTRODUCTION

It is typical of Filipino small farmers, particularly those in the hinterlands, to strive for self-sufficiency and self-reliance in their everyday needs. Foremost among these needs is food. Thus, in the Philippines, many traditional farmers raise vegetables or fruit trees, a few chickens or ducks, and two or three pigs, goats or other ruminants in his piece of land besides the main crop.

In rice fields, farmers trap wild fish during harvest for family consumption. Immediately after harvest. fowls are allowed to feed on rice droppings and other aquatic organisms in the wet fields. During off-cropping season, livestock roam and graze on the paddy field. All these are part of the regular scenery in rural areas.

While the traditional farmer may be contented with what he produces for subsistence and little added income, the more progressive have diversified and expanded their operations to increase profits. Agribusiness enterprises try to arrive at the most efficient and economical allocation of resources for more gainful farm output.

Maximization of the use of land and water resources through integrated farming systems has been receiving more attention lately among agricultural researchers and economists in the country. Compatible and complementary combinations and cropping patterns are being determined to attain optimum potentials in mixed farming arrangements.

There are a number of reasons viewed on a national scale that favor a trend towards multi-commodity farming. Above all, the rapidly growing population demands a sustained increase in food production. The current land reform program of the government limits one family to own not more than seven hectares. And since the landholding will eventually be divided among the children the future farmer who does not have the means to work in the city would be left with even a smaller parcel of land.

The government thrust in countryside development aims at, among others, the improvement of the nutritional level and income-generating capabilities of the rural population. Integrated farming will obviously help the country reach this goal and provide opportunities for under-utilized labor resources. As the general socioeconomic level in the countryside gradually improves, migration to overcrowded urban areas will be minimized.

Another reason is the prevailing energy crisis. Again, as in food supply, self-reliance is a major national goal in the area of energy production. The development of the technology for producing biogas from piggeries as a non-conventional energy source also opens the way for waste utilization in various mixed farming systems. At the same time, the dangers and nuisance of pollution are abated through the waste recycling process.

COUNTRY REVIEW OF INTEGRATED FARMING SYSTEMS

Much of the integrated farming systems now practised in the Philippines were largely evolved through experience and experimentation by the private sector. The more advanced segments have adapted or modified some foreign technologies but few of these are documented. Recent studies by government researchers, however, have had good results and are published in technical reports and some popular literature.

Small-Scale Operations

Integrated farming may be classified according to the main commodity being produced, i.e. with crop, livestock or fish as the major enterprise.

1. Crop-based farming systems

a. Rice-fish

The old practice of trapping wild fish inside rice paddies has been developed into an economically feasible technology by the Freshwater Aquaculture Center of Central Luzon State University (FAC/CLSU).

The irrigated rice paddy is provided with a center trench running lengthwise which serves as fish refuge, passageway and catch basin; the dikes are made slightly higher than in rice monoculture and a gate on the dike is constructed for water entry and drainage. A wire screen is installed at the gate to prevent entry of predatory fishes and escape of stocked fish.

The insect-resistant, high-yielding IRRI rice varieties IR-26, 30, 32, 36, 38, 40 and 42 are used. These varieties have a culture period of 110 to 145 days. The recommended fish species are *Tilapia mossambica*, *T. nilotica* stocked at 3000–4000/ha and *Cyprinus carpio* (common carp) at 3000–4000/ha. In polyculture, stocking rates are 4000 tilapia and 2000 carp per hectare. Culture period for the fish is 80–100 days in rice-fish culture. Experiments so far indicated that use of carbofuran pesticide is not toxic to fish; no residue is left in the fish which is thus safe for human consumption[2].

Results from 19 field trials in 1977–1978 yielded an average on a hectare basis of 116 cavans of palay (50 kg/cavan) and 204 kg of fish per cropping. This corresponds to a mean net income of about ₱ 5,210. more than that of rice culture alone by ₱ 677 (Table 1). The culture method is now undergoing a nationwide pilot implementation phase under the joint sponsorship of the Ministry of Agriculture and Ministry of Natural Resources. Even rice farms outside the pilot areas are gradually adopting the technology.

A major constraint to widespread adoption, however, is shortage of fish seed supply. For the 1.4 million hectares of irrigated ricelands alone, not counting the needs of fish cages and ponds, the fingerling requirement would be 4,200 to 8,400 million per cropping. Since the combined output of all hatcheries in the country cannot supply this, the rice-fish program includes training on fish hatchery management for farmer-cooperators.

b. Rice-vegetable-fish .

The one-hectare farm of Mr. Francisco Carbonel in Nueva Ecija province produces rice, vegetables and fish. The setup includes: 1) tilapia breeding and nursery ponds of approximately 1,000 m^2 total area; 2) rice-fish paddies of about 9,000 m²; 3) slightly raised and widened (1.5 to 2 m) paddy dikes occupying a combined area of 1,000 m²; and 4) an independent and dependable water supply with underground channels running along the dikes to the point of delivery; through this system the dikes may be watered.

The dikes are planted to vegetables such as eggplant, pechay, native onion, tomatoes and beans, as well as some citrus and banana plants. Taro plants, locally known as 'gabi,' are raised along the base of the paddy dikes, but rice is still the major crop. The farmer invested ₱12,000 for this project which has reportedly increased the farm gross income from ₱10,000 to ₱25,000 per year[7].

A similar one-hectare farm was put up in 1977 at the Central Luzon State University for economic feasibility studies and demonstration purposes. The so-called CLSU Model Farm or 'Farm of the Future' consists of: 1) four tilapia nursery and breeding ponds, 698 m² total area; 2) five rice-fish paddy fields, 8,779 m² total area; 3) several elevated, 3–4 m wide dikes for vegetable beds, 2,446 m² total area; 4) an underground channel along the main dike for distributing irrigation water; 5) a pump house; and 6) a farm house made of bricks.

The total development cost amounted to ₱ 57,479, including the cost of the farm house of about ₱11,700. According to Undan, *et al.*[17], the farm produces rice, *Tilapia zillii*, and 15 other crops for a net income of ₱11,656 in one year (Table 2).

Table 1. Cost-benefit analysis of one cropping of rice and rice-fish culture on a hectare basis[8]

Items	Rice culture	Rice-fish culture
	₱	₱
A. Cost of production	2,117.60	2,603.60
B. Production		
1. Rice production (cavan)	122	116
2. Fish production (kg)	—	204.75
C. Value		
1. Rice (₱ 55/cavan)	6,710.00	6,380.00
2. Fish (₱ 7/kg)	—	1,433.25
D. Gross income	6,710.00	7,813.25
E. Net income	4,532.40	5,209.65
F. Additional net income from rice-fish culture	—	677.25

Note: 1 cavan = 50 kg: US$1.00 = ₱ 7.35

c. Fruit-vegetable-pig-poultry-fish

Several multi-commodity combinations are probably practised by the more enterprising farmers the country, but few of these are documented nor their cost-return analyzed.

One such case is the small farm of 1.6 hectares of Ms. Manuela Maramba in Sta. Barbara, Pangasinan province[14]. It has a fruit orchard, vegetable garden, piggery, poultry, and fishpond. The manure from 16 sows and 1,600 broilers are fed into a digester for biogas production. The resulting liquid sludge, known to be a better fertilizer than fresh manure, is used to fertilize the orchard, vegetable garden, and fishpond. The entrails of dressed chicken from the farm, together with chopped banana stalks and vegetable scraps are cooked using biogas fuel for feeding the pigs. The biogas is also used for various domestic purposes.

Ever since waste recycling through biogas operations became popular towards the middle of 1970s, a number of rice-vegetable farms with backyard piggeries have been using the effluents (sludge) from the digester for fertilizing the fields and, in some farms, small fishponds.

Table 2. Summary of the one-year model farm income and expenses (16 June 1978—15 June 1979)[17]

Items	Amount (₱)
A. Gross income	
1. Rice	6,307.60
2. Taro ('Gabi')	5,340.90
3. Onion (cluster type)	4,735.45
4. *Tilapia zillii*	1,482.50
5. Eggplant	730.40
6. Tomato	551.90
7. Pepper	181.25
8. Bitter melon ('Amargoso')	94.45
9. Corn	93.95
10. Sweet potato	82.30
11. Pechay	71.75
12. Stringbeans	66.00
13. Squash	58.30
14. Sponge gourd ('Patola')	46.00
15. 'Condol'	42.00
16. Okra	38.50
17. 'Batao'	17.50
Total	19,940.75
B. Production expenses	
1. Hired labor	763.50
2. Animal and machine fee	2,788.01
3. Supplies and materials	3,082.67
4. Farm rent	1,650.00
Total	8,284.18
C. Net Income	11,656.57

d. Crop-livestock

Livestock production in the country is either of the commercial-ranch type or the backyard type. Because of the observed overstocking or overutilization of current pasture areas, researchers are focusing on the improvement of native grasslands by oversowing them with legumes or by establishing pure grass and grass/legume pastures with fertilization to increase beef production in commercial grazing systems. In the case of backyard or small feedlots, integration with crop farms is favored since the animals subsist mainly on weeds, crop residues and other farm by-products.

In 1976, backyard feedlots were raising some 4.23 million head of cattle and carabao, much more than the total animal population of 495,620 in ranch areas. Still much feed resources are unutilized, considering that an animal population of 11 million can be potentially supported by feed materials coming from a total crop area of 7.93 million hectares planted to rice, corn, sugarcane and coconut. One explanation for this is perhaps most crop fields and livestock feedlots are located in separate places[1].

Thus, for backyard livestock production, a major research thrust is the integration of fodder production with existing cropping systems. A model for an upland farming system based on ipil-ipil (*Leucaena* sp.) grown in hedgerows spaced three meters apart and planted to corn or sorghum in-between has shown good potentials for cattle fattening and leaf meal production.

Ongoing researches are concentrating on: 1) utilization of crop residues, corn stovers, etc. with ipil-ipil, with or without concentrate supplementation; 2) integration of fodder production with existing cropping patterns (rice-cadios; rice-ipil-ipil; corn-cadios; corn-ipil-ipil; tobacco-ipil-ipil, etc.); and integration of fodder crops with intensive cropping systems (fodder soybean with green corn; fodder cadios with upland rice).

e. Coconut-pasture-cattle

Instead of growing crops under coconuts, some farmers raise livestock to free the soil surface of weeds and thus save money on weed control, and at the same time convert the weeds into meat or milk. About 400,000 hectares of the 2.5 million-hectare area under coconuts are currently used for grazing[1].

To improve the pasture, the native grasses are replaced by high-yielding grasses and legumes. Para grass, Guinea grass, Alabang X grass species and Centrosema and Kudzu legumes are found to be satisfactory for grazing purposes[15]. Other legumes like ipil-ipil may also be grown in the same farm as source of feed ingredient for cattle and other livestock.

A 1968 survey of 103 beef cattle farms under coconuts in Mindanao (southern Philippines) showed an average cash income of ₱ 760.58 (in 1968, US$1.00 = ₱ 3.90) from coconut sales and ₱ 49.37 from cattle sales per hectare, for a total net return of P 151.68/ha[15].

As in other integrated systems, however, more research is needed here to obtain the right balance of farm components; pasture crops compete with the coconut trees for nutrients and water, and the animals compact the soil.

2. *Livestock-based farming systems*

a. Pig-crops-fish

The most advanced of these integrated farms is the Maya Farms which will be discussed later. Basically, the sludge from the biogas plant is used as fertilizer for crops and fishponds. Following are examples of predominantly pig-based small-scale operations.

The University of the Philippines at Los Banos (ULPB) has a model recycling system that produces algae, pork, biogas, rice, vegetables and fish[10]. Hog manure and washings are channeled to the digester, and the effluent used as fertilizer for the rice and vegetable fields, tilapia and chlorella ponds. Chlorella, a high protein alga, serves as substitute for soybean oil meal in pig rations, as feed for the fish, and fertilizer for vegetables.

The structures for the system (pig pens, chlorella pond, digester, fishpond, windmill and pipings) were estimated to cost ₱ 18,400 (US$2,453) at 1974 prices. The total income derived from the system is ₱ 19,773 (US$2,636), including sales from pig, rice and savings on energy from methane gas, fertilizer and vegetables. Net profit amounts to ₱ 4,462 (US$595). Tilapia production of 1.1 kg/month from the 7.5 m^2 pond was not valued.

Channeling the sludge from the digester to an algae pond is also done in the swine breeding station of the Bureau of Animal Industry (BAI) in Tarlac province[14]. The liquid from the pond fertilizes a fishpond and a field planted to Napier grass, which in turn serves as pasture for large animals in the stock farm.

Two integrated farms operated by Mr. Jose Sanvictores use entirely liquid hog manure as fertilizer. One of these farms does not have to use chemical fertilizers for the ricefields. In the other farm, the liquid manure is pumped to Napier and Para grass fields; the runoff then goes to a water chestnut plantation; and the overflow to a catfish backyard pond[6].

b. Pig-poultry-cattle-vegetable

The uses of waste recycling are also evident in the Golden Farm in Sta. Maria, Bulacan province, where vegetables are grown in addition to livestock and poultry production[14]. The methane gas produced from hog manure and pen washings is used as fuel for drying chicken droppings to be fed to the cattle; the recovered solid sludge from the digester, as feed material for the pigs; and the liquid sludge, as fertilizer for squash, bitter melon and citrus ('calamansi') plants.

3. *Fish-based farming systems*

a. Fish-pig

The integration of animal husbandry with aquaculture has been reported in many countries in Asia and Central Europe. In the Philippines, such combination has not been extensively practised. Of the few fishfarms that raise pigs to provide manure for pond fertilization, the biggest perhaps is the Jamandre farm which will be presented later.

Preliminary results on fish-pig production at the Freshwater Aquaculture Center (FAC) indicate that fish yields of 5,850 kg/ha in 270 days may be obtained, representing more than 4 times the production of raising fish alone at the same fish density with inorganic fertilization only. The combination used was 60 pigs and 20,000 fish/ha, composed of 17,000 *Tilapia nilotica*, 2,800 *Cyprinus carpio* (common carp) and 200 *Ophicephalus striatus* (mudfish or snakehead), the latter added as tilapia predator to control reproduction[4,16].

In another experiment, brackishwater ponds rearing 4,000 milkfish and 2,000 tilapia per hectare in polyculture are supplied directly with pig wastes washed from pens over the ponds. The system produced a mean of 252 kg of milkfish and 180 kg of tilapia after 120 days, indicating that tilapia performed significantly better than milkfish[3].

b. Fish-chicken or duck

Fish-chicken or duck combinations are not as widely practised, if at all, in the Philippines as in other Asian countries. Chicken manure, however, is purchased and applied in brackishwater milkfish ponds in the country at an average rate of one ton/ha; but the recommended rate of application is 2 tons/ha.

Based on a survey of 1,394 pond operators, 19% used organic fertilizer sources; 26%, organic-inorganic fertilizer combination; and 54%, inorganic fertilizer[13]. Of the organic sources, chicken manure is the most widely used, followed by hog manure, guano and composts. Another survey found that 42% of fully developed milkfish ponds sampled had less than 4% organic matter[5]. Pond soils should have at least 9% organic matter to obtain abundant algae growth for fish food. Considering these data, the economic feasibility of integrating chicken and fish production may be worth looking into.

The duck farming industry around the Laguna de Bay lake, while accounting for more than 700,000 ducks in about 4,000 duck farms, is not integrated with fish production in the strict sense. However, the duck manure and domestic wastes draining into the lake enhance biological productivity in the water, which is evidently responsible for the high 4 ton/ha/yr production levels in milkfish culture pens in the lake; the ducks, in turn, feed on the snails and small shrimps collected by farmers from the lake[9].

Fish-duck integration is being tried also at the FAC. Initial tests indicate maximum stocking rates of 750 Pekin ducks and 20,000 fish/ha with the same fish composition used in the fish-pig experiment earlier mentioned. With this combination, the maximum net fish yield after ducks have become regular layers would be 5,070 kg/ha in 270 days[4].

c. Fish-taro

Experiments are underway at the CLSU using rice paddies as shallow fishponds for simultaneously growing tilapia and taro (*Colocasia esculenta*). One setup has elevated plots for the plants and trenches for the fish. Another system has the whole pond planted to taro at plant spacing similar to rice culture. Since taro now sells at ₱ 1.00 per plant in Nueva Ecija province, a 200 m^2 paddy with 1,000 plants would gross ₱ 1,000, as compared to 3 cavans of palay production from the same area worth about ₱ 150 only (dela Cruz, pers. comm.).

Large-Scale Operations

Except for the Maya Farms, records are not available to the author of large-scale integration and waste recycling in other agro-industrial farms in the country. It is conceivable though that livestock feedlots may be found in big pineapple and banana plantations to utilize the agricultural and processing wastes. There are unpublished information of one sugarcane plantation planning to utilize excess irrigation water from its reservoir for fish-pond culture purposes, and a forestry concern raising fresh-water fishes in natural water impoundments in the watershed.

Two case studies are presented here to illustrate the development of integrated farming systems in the Philippines achieved through private initiative.

1. Pig-rice-corn-vegetable-fish

Maramba[14] describes the operation of Maya Farms, the agro-industrial division of Liberty Flour Mills, Inc., in his book on 'Biogas and Waste Recycling.' The 24-hectare farm complex in Antipolo, Rizal province integrates hog raising with slaughtering, meat processing and canning, as well as feed mixing, crops and fish production.

The biogas works eliminate odor pollution caused by the manure from 10,000 pigs, and at the same time produce biogas useful in many operations in the farm: cooking in rendering and canning plants; heating the scalding tanks in the slaughterhouse and cooking vats in meat processing plant; running gas refrigerators, water heaters, deepwell pumps, old engines for pumping manure slurry; providing power for feed mills, corn grinder in feed mixing plant, etc.

Scraps and wastes from the slaughterhouse, meat processing and canning plants are processed into meat meal, bone meal and blood meal. These are used as ingredients in preparing hog feeds in the feed mixing plant.

Sludge conditioning takes place in settling basins and lagoons; the settled solids are recovered, dried and processed into feed materials. A waterwheel driven by a windmill helps aerate the remaining liquid sludge in a series of lagoons to remove toxic substances and produce better fertilizer.

Irrigation water from the lagoons fertilizes sweet corn and vegetables needed in the canning plant. In place of these crops, rice is grown during rainy seasons. The liquid fertilizer and feed sweepings from the pig pens also induce plankton growth in fishponds which yield about 2 tons of tilapia per hectare in three months.

The total waste recycling system costs more than ₱750,000 to develop, and it has now become a highly profitable enterprise partly due to savings in energy cost, recovered feed materials, and added income from crops and fish.

2. Fish-pig-cattle-coconut

From his observation in other countries and local biogas operations, Mr. Ernesto V. Jamandre decided to put up a piggery in his 120-hectare milkfish pond in Iloilo province. Before that, the newly-constructed brackishwater ponds initially gave low fish yields; when he later applied raw sewage from the pig pens, the pond soil improved and the fish yields gradually increased. Aside from milkfish, the ponds also raise shrimps and tilapia.

Two piggery units are found in the farm. One supplies clear water effluent from a digester to the nursery ponds. The second unit has a four-compartment treatment tank added to the digester. The sludge from the last compartment can be directed through plastic hoses to six grow-out ponds, totalling about 60 hectares.

In 1977, Jamandre reported a total pig stock of around 1,200, including 134 sows (hybrids of Hypors, Yorkshire, Landrace and Hampshire) and 8 boars of pure breeds.

Certain operational constraints beset the farm, like difficulty in transporting supplies and marketable pigs. The site is 16 km from Iloilo City and materials have to be transported across a river by boats. Feed materials are scarce at times and, if available, cannot be stored over long periods. The initial investment is very high: at the ratio of 2.2 sows per hectare of pond, the cost of pigs and facilities for maintaining the animals and their litters amounts to ₱11,000/ha.

Furthermore, most experiences in other countries in pig-fish combinations involve freshwater fishes. More studies are needed to test the effectiveness of using hog manure for milkfish culture in brackishwater ponds. No economic analysis is available to show if the increase in fish yields and savings on chemical fertilizer compensate for the cost of hog feeds.

The farm also includes about 35 head of cattle which graze on the 6-meter wide principal dikes and about 16 hectares of grass area under coconut trees adjoining the fishponds (Alicer, pers. comm.).

CONCLUSION

Integrated farming systems is still a wide-open field for multidisciplinary research in the Philippines. Several technologies developed elsewhere remain to be verified under different environmental conditions. A more systematic approach for testing various combinations must be developed to determine the appropriate stocking densities or carrying capacities for each system component, the optimum resource allocation and complementation among commodities, the full employment of labor resources, and so on. The objectives should be to identify the most profitable crop-animal mixes for specific conditions.

Together with the technology package, cost-return evaluation of operation farm systems have to be documented and disseminated. Credit support has to be provided and integrated farm operations on a wider scale should be promoted.

REFERENCES

1. Alferez, A. C. 1979. Technology Generation, Verification and Dissemination in Forage Pasture and Grasslands. PCARR Forthnightly Seminars. Sem. Paper Series No. 23. Los Banos, Laguna, Philippines.
2. Arce, R. G. and C. R. de la Cruz. 1978. Improved Rice-fish Culture in the Philippines. International Commission on Irrigation and Drainage (ICID), 2nd Reg. Afro-Asian Conference. Tech. Paper. Manila, Philippines.
3. Aure, R., R. Fortes, R. Sanares. 1978. Utilization of Agricultural By-products and Wastes for Fish Culture. Ann. Rept. 1978, UPCF Brackishwater Aquaculture Center. Leganes, Iloilo, Philippines. 28 p.
4. Cruz, E. M. and Z. H. Shehadeh. 1979. Preliminary Results of Integrated Pig-fish and Duck-fish Production Tests. ICLARM-SEARCA Conf. on Integrated Agriculture-Aquaculture Farming Systems. Contributed Paper. Manila, Philippines.
5. Davide, J. G. 1979. Fishpond Fertilization in the Philippines. PCARR Forthnightly Seminars. Sem. Paper Series No. 27. Los Banos, Laguna, Philippines.
6. dela Cruz, C. R. 1976. Updated Benchmark Information on Fish Farming Integrated with Crop and Livestock Production. *In* Proc. Soils and Water, Sec. Nat. Agric. and Res. System Res. Cong., PCARR, Los Banos, Laguna, Philippines.
7. ————————. 1976a. Integrated Agriculture-Aquaculture Farming Systems in the Philippines. ICLARM-SEARCA Conf. on Integrated Agriculture-Aquaculture Farming Systems. Country Report. Manila, Philippines.

8. dela Cruz, C. R. 1979b. Technical Justification of Rice-fish Culture Program. Paper prepared for NFAC. Manila, Philippines.
9. Delmendo, M. N. 1979. A Review of Integrated Livestock-Fowl-Fish Farming Systems. ICLARM-SEARCA Conf. on Integrated Agriculture-Aquaculture Farming Systems. Manila, Philippines.
10. Eusebio, J. S., R. Rabino and E. C. Eusebio. 1976. Recycling System in Integrated Plant and Animal Farming. NSDB-UPLB Integrated Research Program Technical Bulletin 1 (1). UPLB, College, Laguna, Philippines. 30 p.
11. Guerrero III, R. D. 1979. Paddy Culture of Fishes and Invertebrates. Thursday Seminar of IRRI. Sem. Paper. Los Banos, Laguna, Philippines.
12. Jamandre, E. V. 1977. Integrated Piggery and Milkfish Culture: Some Problems and Constraints. *In* Proc.; Joint SCSP/SEAFDEC Workshop on Aquaculture Engineering. Iloilo, Philippines.
13. Librero, A. R. and E. Nicolas. 1979. Socio-Economic Aspects of Milkfish Farming in the Philippines. SEAFDEC/PCARR Technical Consultation on Available Aquaculture Technology in the Philippines. Iloilo, Philippines.
14. Maramba, Sr., F.D. 1978. Biogas and Waste Recycling: The Philippine Experience. Maya Farms Div., Liberty Flour Mills, Inc. Regal Printing Co. Manila, Philippines. 230 p.
15. Philippine Council for Agriculture and Resources Research (PCARR). 1976. The Philippines Recommends for Integrated Farming Systems. Los Banos, Laguna, Philippines. 92 p.
16. Quines, O. D. and E. M. Cruz. 1979. Preliminary Study on the Use of Pig Manure for Fish Production. Phil. Soc. of Animal Science 16th Ann. Convention. Contributed Paper. Manila, Philippines.
17. Undan, R. C., R. S. Cabanilla, R. M. Cabrera, E. B. Tiburcio, D. Soberano and N. Tamayo. 1979. Ann. Rept. on the Operation of the CLSU Model Farm. Munoz, Nueva Ecija, Philippines. 11 p. (Mimeo.).

DISCUSSION

Q. Methane gas generation, while having existed in Taiwan for many years, is not widely used because of the high cost of investment; now-a-days, propane gas is more convenient to use and also, electricity in Taiwan is not expensive. In the Philippines, how long do you recover your investment?

A. At Maya Farms, we recover the investment after 2 years; if we count the gas generated from it, it will take 7½ years to recover; but if we count the feed (solid sludge– 10% biofeed) that we get (2.5 tons of feed per day from 15,000 pigs,) then recovery of investment is shorte

Q. What are the ages of the 15,000 sows at Maya Farms?

A. 1,500 sow unit plus all weanlings; one sow unit = one sow + all offsprings up to 7 months old.

INTEGRATED FARMING IN THAILAND

by

Somsak Janesirisak

INTRODUCTION

The progress of fish culture in Thailand is noticeable. Approximately, a total area of 23,568 ha in 20,974 farms are used for fish culture. At present our fish farmers are using modern technologies instead of old methods. Fish farmers can produce a high fish yield by using spawning techniques that artificially induce fishes such as chinese carps, etc. to spawn. This enables farmers to have more fingerlings than they need and they can therefore sell excess fingerlings to other farmers.

The farmer's critical problem is lack of capital because feeds are expensive while the price of their products is not proportionate to the price of feed. They incur losses due to the imbalance between investment and profit. Therefore, farmers try to reduce the cost of feed through integrated farming. Instead of raising fish only, the farmer also grows livestock such as pig, chicken etc. Excrements of these animals are directly utilized by fish or used to enrich the pond for the growth of natural fish food organisms such as phytoplankton and zooplankton. It was found that about 60% of the daily consumption of the pig is excreted as feces and urine. Therefore, fish can directly consume it and the valuable nutrients that these contain cause the growth of natural food organisms (Table 1).

With this type of farming, all areas are utilized for maximum yield and production. Pens are built over the fish pond or near the edge of the pond, and economic plants such as banana and coconut trees are grown on the dikes or near by for more profit.

Table 1. Chemical composition of pig excrements

Components	From 100 kg of excrement (kg)
Water	71
Organic matter	25
Nitrogen	0.5
Phosphorus (P_2O_5)	0.4
Potassium (K_2O)	0.3
Calcium	0.09
Others	0.9

Adopted from Woynarovich, 1976.

LIVESTOCK-FISH COMBINATION

There are two popular ways of building the pen in Thailand:

1. Those made of wood or bamboo built over the fish pond so that animal excrement fall into the pond.

2. Pens are built on the edge of the pond, with concrete floor sloping down towards the latter. This is more expensive than the first one.

Culture Species

There are quite a few species which the farmer may raise in the ponds in combination with live-stock (Table 2).

Table 2. Preferable fishes

Thai name	Common name	Scientific name
Pla nile	Nile	*Tilapia nilotica*
Pla song	Bighead carp	*Aristichthys nobilis*
Pla Tapien	Puntius	*Puntius gonionotus*
Pla swai	Catfish	*Panqasius sutchi*

To avoid water pollution and provide enough organisms for fish, it is necessary to know the stocking rate of fish and number of animal to be raised in combination with fish. The results of research on this area conducted by the Extension Unit of the National Inland Fisheries Institute (NIFI), Bangkok, Thailand are summarized in Table 3.

Table 3. Number of pigs and fishes in one rai pond

Species of fish	One rai pond	
	No. of pigs	No. of fishes
1. *Tilapia nilotica*	7–10	1,600
2. *Pangasius sutchi*	10	1,000
3. *Puntius gonionotus*	8	4,000
4. *Aristichthys nobilis* and	7	150
Tilapia nilotica	7	1,600

1 hectare = 6 Rai

Yield from Fish/Pig Raising

Research results are shown in Table 4.

Table 4. Yield from fish/pig raising

Fish species	Population	One Rai pond			
		Initial wt. (gm/fish)	Fish rearing period (month)	Total yield* (kg)	Ave. wt./fish (kg)
Tilapia nilotica	1,600	30	6	600	0.375
Pangasius sutchi	1,000	2.0	14	400	0.40
Puntius gonionotus	4,000	2.5	10	500	0.125
Aristichthys nobilis and	150	100		200	1.33
Tilapia nilotica	1,600	30	6	400	0.25

* Yield is after 6 months

Returns from Pla Nile (*Tilapia Nilotica*) in Combination with Pigs

Results of the survey from three farms at Soi Sena Nikom 1, Pahol, Yothin Road, Bangkhen, Bangkok, Thailand are shown in Table 5.

Table 5. Returns from *Tilapia nilotica* in combination with pigs at Soi Sena Nikom 1, Bangkhen, Bangkok, Thailand (Baht)

Details	Farm No. 1	Farm No. 2	Farm No. 3
Pig			
No. of pigs	45	100	100
wt. (kg)	8–10	8--10	8–10
Cost of young pigs	20,250	50,000	50,000
Feed and medical care	26,311	19,720	44,500
Rented area	—	6,000	—
Period of raising (month)	7	8	8
Total wt. (kg)	8,400	11,000	12,000
Average wt. (kg)	120	110	120
Price (Baht/kg)	18	18.50	—
Total income (Baht)	97,200	203,500	228,000
Pla Nile			
Area of pond (Rai)	4	6	10
Number of fish	15,000	25,000	200,000
Cost of fingerlings	1,500	1,250	10,000
Fish rearing period (month)	6	6	7
Total wt. (kg)	2,500	3,100	5,000
Average wt. (kg)	0.250	0.250	0.100
Price (Baht/kg)	8	8	6
Total income	20,000	24,800	30,000
Grand total income	117,000	228,300	258,000
Grand expense	48,061	136,970	204,500
Profit	69,139	91,330	53,500

1 US$ = 20 Baht

CONCLUSION

The number of integrated farming in Thailand is increasing. It is however necessary to determine the optimum density between the fish and animals and to improve the management of the system to get the highest income at the lowest cost. From the data, the conversion rate of excrement from one pig is roughly 31.00–55.55 kg of fresh fish.

REFERENCES

Potcharoen Chitta and Somsak Janesirisak. 1977. Integration of Swine and *Tilapia nilotica*. Ext. Bul. No. 1 Extension Unit National Inland Fisheries Institute (NIFI), Bangkhen, Bangkok, Thailand. (In Thai).

Vit Thanchalanukit. 1978. The Application of Pig Manure for Fish Ponds. Tech. Paper and Instructed Paper. Fish Culture Section, Faculty of Fisheries, Kasetsart University, Bangkok, Thailand.

Woynarovich, E. 1976. The Feasibility of Combining Animal Husbandry with Farming, with Special Reference to Duck and Pig Production. FAO. Tech. Conf. Aqu . Expt. Pap. No. 6. Kyoto, Japan. p. 11.

DISCUSSION

Q. In your stocking, you used *Tilapia nilotica* and carp. In the Philippines, we have bad experience with *T. nilotica* if stocked without predator; we have to control reproduction otherwise it is impossible to obtain as much yield as you did. What is your experience regarding this matter?

A. There are two things that we do: 1) we try to separate male and female; 2) we separate fingerling in one pond and then stock in another pond.

Q. How can your cost of feeds be too low? Do you use corn for pigs?

A. Feeds for pigs are left-over food from restaurants. We do not use corn for pigs; Thailand exports it.

Q. On Table 5, how much is your labor input in production of pigs?

A. Labor utilized was family labor thus, no costing was placed.

214

INTEGRATED FARMING IN CHILWON VILLAGE: A CASE STUDY

by

Youl-Mo Dong

INTRODUCTION

Farming in Korea is characterized by small scale grain production on an average cultivated land area of 0.97 hectare per farm household, using predominantly family labor (Tables 1 & 2).

As seen in Table 1, approximately 68 percent of the total farm households have less than one hectare; 31 percent have less than 0.5 hectare with which they can hardly sustain the subsistence of their families; about 31 percent of the total farm households possess only 11 percent of the total arable land. Table 2 shows that on average, 5.7 family members are depending for their livelihood on 0.97 hectare of arable land by means of labor-intensive farming with 2.9 working members per farm household. It is worthwhile to pay attention to the size of holding per farm worker which averages 0.34 hectare or 3,400 square meters. Especially in the group with less than 0.5 hectare, 0.14 hectare or 1,400 square meters is managed by one working family member. These figures demonstrate the excessive labor force to land holding ratio which has caused seasonal unemployment.

Such factors have necessitated high utilization of farm land labor and intensive management in terms of integrated or diversified farming.

It has been customary to grow cereal crops, rice in summer and barley in winter after harvesting rice in the southern part of Korea. Consequently, farming in Korea is largely dependent on land, which is the most serious restricting factor in improving rural conditions. In other words, the rich or poor farmer can be identified by the size of his cultivated land holding.

Table 1. Distribution of farm household and arable land area by size of holding (1977)

Classification	Under 0.5 ha	0.5—1.0 ha	1.0—1.5 ha	1.5—2.0 ha	Above 2.0 ha	Total
Farm population	—	—	—	—	—	12,308,834
Farm household	686,082	795,331	406,841	170,475	131,552	2,190,281
Percentage	31.3	36.3	18.5	7.8	6.1	100.0
Arable land	217,265	583,155	494,871	292,577	365,807	1,954,675
Percentage	11.1	29.8	25.4	15.0	18.7	100.0

Source: MAF, Reports on Farm Household Economy Survey.

Table 2. Size of farm families and number of farm workers by size of holding (1974)

	Under 0.5 ha	0.5—1.0 ha	1.0—1.5 ha	1.5—2.0 ha	Above 2.0 ha	Average
No. of family member	4.7	5.5	6.2	6.6	6.8	5.7
Arable land per household (ha)	0.31	0.73	1.25	1.71	2.68	0.97
No. of farm-engaged member per household	2.3	2.8	3.3	3.2	3.6	2.9
Size of holding per farm worker (ha)	0.14	0.26	0.38	0.53	0.74	0.34

Source: MAF, Reports on Farm Household Economy Survey

However, the demand for income-elastic farm products like vegetable and animal protein foods increases as the standard of living condition is upgraded (Table 3). Farmers are forced to integrate farm management patterns with grain plus vegetable or livestock production to maintain economic viability and maximize utilization of resources. Considering limited cultivated land and the long winter season, integrated crop-livestock farming has more potential than crop-vegetable for small farmers. They usually grow rice in summer season and forage crops after or before rice cultivation to feed to herbivorous animals.

Table 3. Changing food supply pattern (pers/day)

Classification	1962	1967	1972	1977
Calorie (kcal)	1,943	2,216	2,415	2,427
Index	100.0	114.1	124.3	124.9
Rice (g)	331.4	341.3	341.5	346.3
Index	100.0	103.0	103.0	104.5
Vegetables (g)	99.0	129.2	170.6	171.2
Index	100.0	130.5	172.3	172.9
Meats (g)	17.3	28.0	34.8	41.1
Index	100.0	161.8	201.2	237.6

Source: MAF and Korea Rural Economics Institute, Reports on Food Supply Pattern in Korea.

Integrated crops-livestock farming with Korean native cattle has been popular among small farmers not only for the draft power provided by cattle but also as an important family asset. As dairy and beef cattle have been introduced in recent years in addition to the native cattle, integrated crop-dairy farming is becoming popular in suburban areas. In remote mountainous areas, integrated crop-beef cattle as well as native cattle farming is common. Table 4 shows the popularity of such integrated farming in Korea.

Table 4. Number of head and farm household raising cattle by size (1978)

Cattle	Classification	Total	1—9 head	10—29	30—49	Over 50
Native cattle	Head	1,624,301	1,593,713	17,068	4,500	9,020
	(%)	(100.0)	(98.1)	(1.1)	(0.3)	(0.5)
	Farm household	1,169,784	1,168,476	1,120	125	63
	(%)	(100.0)	(00.888)	(0.096)	(0.011)	(0.005)
Beef cattle	Head	27,054	12,309	3,071	564	12,110
	(%)	(100.0)	(45.5)	(7.6)	(2.1)	(44.8)
	Farm household	6,081	5,886	138	16	41
	(%)	(100.0)	(96.8)	(2.3)	(0.2)	(0.7)
Dairy cattle	Head	135,803	48,747	50,832	14,276	21,948
	(%)	(100.0)	(35.9)	(37.4)	(10.5)	(16.2)
	Farm household	16,387	12,438	3,343	393	213
	(%)	(100.0)	(75.9)	(20.4)	(2.4)	(1.3)

Source: Livestock Industry Development Corporation

Despite the fact that the government has tried to establish large-scale livestock farms and has strongly supported them in many ways since early 1970s, most of the cattle are raised by small farmers. Table 4 shows that the large farmers raising more than 50 head account for only 16 percent of total head of dairy, 45 percent of beef cattle and 0.6 percent of Korean native cattle. On the other hand, small farmers who raise less than 9 head hold a large portion of the cattle: 36 percent of total head in dairy, 45 percent in beef cattle and 98 percent in native cattle.

The number of farm households raising less than 9 head is 76 percent of total dairy farmers, 97 percent of beef cattle farmers and almost 100% of native cattle farmers.

THE CHILWON VILLAGE PROJECT

Chilwon village is situated in the middle part of the Korean peninsula with accessible transportation directly connected by the express highway and railroad to the capital city of Seoul and the other cities throughout the country. The village has 46 households with a population of 286 persons. Of the total households, 38 make their living by farming an average cultivated land area of 1.6 hectares per household.

The village was poverty-stricken until late in the 1950s; farmers depended for their marginal subsistence on small rice and barley cultivation. To make up for the small size of their farms, farmers had to sell wood in nearby towns to supplement their livelihood. Late in the 1950s, however, the teen-agers of the village were ambitious enough to organize a study group, namely the 4-H club, under the guidance of the extension worker responsible for the district. They helped their parents with farming in the daytime and studied by themselves in the evening under the leadership of the village leaders.

The cooperative efforts of the villagers were recognized and the Office of Rural Developmen designated it as one of the 154 integrated development pilot villages for income increase and statione an extension worker there for intensive guidance in 1973.

Adoption of Integrated Crop-Livestock Farming with Dairy as the Major Enterpri

After consultation with the extension worker some of the small farmers began to adopt dai farming. Their integrated crop-dairy farming is focused on optimizing available family labor and sm farm land.

In the case of the rice-forage crops system on paddy land, cold-resistant crop such as rye is gro for silage after the rice harvest in the middle of October until early part of May the following year j before rice transplanting. On upland, integrated corn-vegetable-rye system is common. Such integra crop-dairy farming attracted neighboring farmers and the number engaged in this system increa yearly (Table 5).

Table 5. Number of farm households engaged in dairy farming by year

Year	Number of farm household	Total head of dairy cattle
1973	—	—
1974	5	38
1975	12	91
1976	14	124
1977	17	152
1978	19	173
1979	22	196

Of the total of 38 farm households, 22 have engaged in this type of integrated farmir 196 head of dairy cattle, averaging about 9 head per household as of the end of August 1979.

The village experience offers some significant facts to those who are interested in rural c ment. Table 6 clearly shows that their farm income sources have shifted from crops to dairy (Table 6).

The portion of income from crops decreased by about 59% from 95.5 to 36.9% during a p six years. On the other hand, the portion from livestock increased from 4.5% to 63.1% in period. It is an especially noticeable fact that income from dairying accounted for 82% of livestock income as of the end of 1978.

Another fact worth noting is that the rate of annual income increase per farm household between 1973 and 1978 varied depending on the size of land holding (Table 7). During the period of six years from 1973 to 1978, while the annual income increase for farmers with more than two hectares is 415%, that for small farmers holding less than 0.5 hectare is 844%.

This shows that the gap of income between the size of holding is remarkably narrowed. Table 7 seems to indicate the hard work exerted by small farmers and the effort they have put in to maximize the utilization of their own idle resources.

Table 6. Comparison of farm income sources per household between the first year of the program and the end of 1978

Field	Income sources	1973		1978	
		Amount	%	Amount	%
Crops	Cereal crop	828	90.8	2,039	73.3
	Vegetable	72	7.8	393	14.3
	Orchard	—	—	210	7.5
	Others	13	1.4	137	4.9
	Sub-Total	913	100.0	2,779	100.0
	% of total		95.5		36.9
Livestock	Dairy	—	—	3,891	82.0
	Cattle fattening	21	48.6	771	16.3
	Others	22	51.4	81	1.7
	Sub-Total	43	100.0	4,743	100.0
	% of total		4.5		63.1
	Total	956	100.0	7,522	100.0

Table 7. The annual income increase by size of land holding; comparison of 1973 with 1978

Year	Classification	Under 0.5 ha	0.5—1.0 ha	1.0—2.0 ha	Above 2.0 ha
1973	Amount of income	341,569	578,593	731,049	1,458,001
	Rate (%)	100.0	100.0	100.0	100.0
1978	Amount of income	2,882,694	4,363,621	4,535,162	6,053,379
	Rate (%)	844.0	754.2	620.4	415.2

INTEGRATED FARMING IN MALAYSIA

by

Ali Bin Ismail

INTRODUCTION

Tricommodity integrated farming is a systematic method of raising a combination of livestock, fish and crops. Although this system of farming is practised to a certain extent in Malaysia, it is not as yet being fully exploited by the majority of the farmers. This may be due to several factors, one of which is that the techniques are not widely known among the farmers.

The most widely practised system among pork eaters in Malaysia is the pig-fish-vegetable combination. There is a great potential in developing other combinations, such as those involving ducks and chicken which are acceptable in all Malaysian communities.

At present, not much research are being done on integrated farming. There is a need to identify and verify existing recyling methods and find ways to increase the efficiency of the system.

THE PRESENT STATUS OF INTEGRATED FARMING IN MALAYSIA

The systems of integrated farming which have been identified in Malaysia are as follows:

1. Livestock-cum-crops
2. Fish-cum-crop
   a. Fish-cum-padi culture
   b. Fish-cum-vegetable culture
   c. Fish-cum-fruit trees culture
3. Fish-cum-livestock
   a. Fish-cum-pig culture
   b. Fish-cum-duck culture
   c. Fish-cum-chicken culture
   d. Fish-cum-geese culture
   e. Fish-cum-cattle culture
   f. Fish-cum-goat culture
4. Fish-cum-livestock-cum-crop culture
   a. Fish-cum-pig-cum-vegetable culture
   b. Fish-cum-duck-cum-vegetable culture

c. Fish-cum-pig/chicken/duck cum vegetable culture
d. Fish-cum-goat/buffaloes-cum vegetable culture.

Systems involving two commodities are relatively well known in Malaysia. On the other hand tricommodity integrated farming is employed by some Chinese farmers, whereby pig or duck is produced together with fish and vegetable.

Thus there is a possibility of popularizing tricommodity integrated farming among farmers in fish farming areas in this country. A survey in 1979 indicated that out of 12,000 acres (4,800 hectares) of fish ponds, 6,716 acres are utilized for fish-cum-livestock mixed farming.

A. *Fish-cum-pig culture*

In the fish-cum-pig culture, the waste water from pigsties is channelled directly into fish ponds to fertilize the ponds. The pigs are fed with a soft diet composed of boiled succulent vegetable feeds consisting of any or combination of the following crops: 1) sweet potato (*Ipomoea batatas*) haulms and tubers; 2) cassava (*Manihot* sp.) leaves and tubers; 3) banana stems; 4) kangkong (*Ipomoea reptans*); 5) *Colocassia* and *Dioscorea* sp.

De la Mare[4] reported that in a case study in Penang, Malaysia fish-cum-pig culture involving grass carp, common carp, silver carp and tilapia yielded 3,260 lbs (1,480 kg) for fish per acre per annum (3,655.6 kg/ha).

B. *Fish-cum-chicken culture*

Fishes such as grass carp, big-head carp, Indonesia carp and the Malaysian freshwater prawn (*Macrobrachium rosenbergii*) may be cultured with chicken. At the Malaysian Agricultural Research Development Institute Station (MARDI), Malacca, the culture has been experimented. A poultry shed was built above the fishpond and at the end of 4 months, 242 kg (597.74 kg/ha) of *Macrobrachium* and an equal amount of fish were obtained per acre[1]. The chicken weighed 1.2–1.8 kg each. Ang[1] also reported that in Sarawak, Malaysia 100 chicken can keep one acre (0.4 ha) of pond constantly productive.

C. *Fish-cum-duck culture*

This system is commonly practised by some farmers. Disused mining pools are utilized for culturing fish, consisting of grass carp, silver carp and bighead carp. Adjacent to the pools the farmers cultivate vegetables, rear pigs and some ducks. It has been indicated by MARDI, Malacca, that polyculture of prawn and fish with duck is feasible[1]. In this case, the fish were not given supplementary feeds.

D. *Fish-cum-cattle culture*

In this system the cowbyres are built near fish ponds so that cowdung are easily transported and applied in the ponds at specified intervals.

The common practise in Malaysia is to apply cowdung at the rate of 450 katis per acre per annum (272 kg/hectare/annum).

RECYCLING METHODS

The recycling method commonly practised in Malaysia is best described by De La Mare[4]. He showed that the Chinese farmers engaged in intensive vegetable gardening replenished soil nutrients by integrating pig rearing into their farming system. Pig dung is utilized for manuring vegetable garden, fertilizing pond and replenishing nutrients in padi land.

Pig is the essential biological factor in the production cycle and water is the essential physical factor. Water is needed for pigs, vegetables, rice and fish. The trimmings from vegetables are given to pigs and poultry. Vegetables like kangkong (*Ipomoea reptans*), sweet potatoes (*Ipomoea batatas*) cassavas, and stems of spent bananas are chopped up for hog feed.

BENEFITS OF THE SYSTEM

In Malaysia 71% of the population of 10 million is classified as rural. Eighty-eight percent of the household in the poverty group is in the rural areas and 68% of this poverty group is in the agricultural sector.

Since there is high concentration of small holdings below 10 acres (4 hectares), a program to utilize fully and efficiently the resources available in the farm, through better recycling methods will definitely benefit the farmers. The advantages of this system are:

1. *Increasing the income of small-holders*

Income of rural households varies from M$50.00 to M$1,000 per month or US$23 to US$465[6]. However, a total of 38.7% of these households earn less than M$200.00 (US$93.00) per month. The poverty level in Malaysia is estimated at M$256.00 (US$119.00) per household per month.

Thus a farmer should utilize his land for crops, livestock and fish.

In Thailand, a farmer can increase his net earnings by 20 to 100 times by engaging in fish farming in a part of his rice farm[1]. It was also reported that in Indonesia a rice farmer can earn 70% of his income from the sale of fish from 1/3 of his 1.5-hectare farm.

2. *Cheap source of protein for the rural people*

The weighted average of protein requirement per caput/day has been calculated in 1970 at 35.3 gm in Malaysia[5]. The daily protein consumption of 56.1 gm per caput in 1973 in Malaysia if compared to the per caput requirement of 35.3 gm will show that the protein requirement has been exceeded by 60%. However, this does not necessarily indicate that there is no protein deficiency and malnutrition in the population. A study (Chong and Lim, 1975) indicated that protein intakes are marginal, particularly in the remote inland villages.

3. *Increasing the availability of feeds for livestock in smallholders' farms*

Livestock are classified into monogastrics (non-ruminants e.g. pigs and poultry) and ruminants (e.g. goat, cattle and buffaloes). The ruminants are able to utilize forages and roughages and they do not require cereals and high protein diets. Between 1970–1976, Malaysia imported about 300,000–400,000 tons of feedstuffs annually[2].

Thus efforts should be made to replace partially these feedstuffs by using locally produced raw materials and utilizing agro-based by-products from crops and livestock.

THE POTENTIAL FOR TRICOMMODITY INTEGRATED FARMING IN MALAYSIA

There is a great potential for developing tricommodity integrated farming in Malaysia. There are at present more than 4,800 hectares of fish ponds in Malaysia[3]. It is estimated that additional areas of more than 24,300 hectares, could be developed further for freshwater fish culture and that about half of this area plus the existing 4,800 hectares could be utilized for integrated farming with crops and livestock including chicken, ducks and pigs.

Several types of fruit trees and certain short term crops and vegetables which are popularly grown by local farmers may be integrated into these farming systems. These crops include mangoes, bananas, oranges, lime cassavas, *colocassia*, sweet potatoes, *Dioscorea*, *Ipomoea reptans* and other leafy and fruit vegetables.

PROPOSED DEVELOPMENT PROGRAM

At present, there are no specific government program to provide incentives for farmers to adopt integrated farming, especially those involving three commodities namely fish, livestock and crops.

The program for integrated farming proposed in this paper is in line with the recommendations stated in the Malaysian Agricultural Policy[6] and includes the following:

a. Fish-cum-chicken-cum crop culture.
b. Fish-cum-duck-cum crop culture.
c. Fish-cum-pig-cum crop culture.

Fish-cum-chicken-cum-crop culture

1. The recommended stocking rate for chicken is 100 per acre (250 chicken/hectare) per 4 months. The average weight of each chicken after 4 months is expected to be 1.8 kg.

2. The stocking rate of fish per acre (a total of 540 fish/acre/crop or 1,350 fish/ha/crop):

a. 5,000 freshwater prawn (*Macrobrachium rosenbergii*)
b. 250 grass carp (*Ctenopharyngodon idellus*)
c. 120 big head carp (*Artistichthys nobilis*)
d. 100 Indonesian carp (*Puntius gonionotus*)

Fish will be harvested every 9 months. A conservative production rate at 0.5 ton per acre/harvest (1.25 tons/hectare) is expected.

3. Certain short term crops may be integrated into this farming system. Such crops could include cassava, kangkong (*Ipomoea reptans*) and banana. The vegetative parts of banana, kangkong and cassava may be used as feeds for fish. Other leafy and fruit vegetables may also be integrated into this system.

4. Chicken dung is used as manure, for both crops and fish.

Fish-cum-duck-cum-crop culture

The stocking rate for ducks is 100 ducks per acre per 4 months (250 ducks/hectare) over 2 crops per year.

The stocking rate for fish per acre is similar to that for fish-cum-chicken culture.

Fruit trees, short-term crops and vegetable may be cultivated. The dung may be used as manure for both crops and ponds. In Hongkong it was estimated that 2,000 ducks can provide 30 tons of dropping equivalent to 33 tons of poultry droppings, or 10 tons of pig wastes annually[7].

Fish-cum-pig-cum crop culture

The stocking rate for pigs is 12 pigs per acre (30 pigs/hectare) of 2 crops a year.

The stocking rate of fish per acre (a total of 850 fish/acre/9 months or 2,125 fish/hectare/9 months):

a. 50 grass carp (*Ctenopharyngodon idellus*)
b. 200 big head carp (*Aristichthys nobilis*)
c. 100 silver carp (*Hypopthalmichthys molitrix*)
d. 500 Lee Koh (*Cyprinus carpio*)

The average weight of each pig after 6 months is 130 katis (214.5 kq)

The crops recommended are those which are usually used for both pig feeds and for human consumption. These crops include cassava, *Colocassia*, *Dioscorea*, banana and *Ipomoea* sp.

Polyculture of fish in this system encourages maximum utilization of pond resources. Indonesian carp and grass carp feed on vegetable matter. Big head carp and silver carp feed on planktons which flourish on organic manures from livestock. Common carp (*Cyprinus carpio*) and freshwater prawn (*Macrobrachium rosenbergii*) are bottom feeders and are generally omnivorous.

In the polyculture system, a higher stocking rate for grass carp is used compared to that of Indonesian carp. These two fishes have similar food habits but the Indonesian carp is more active than the grass carp. A lesser number of Indonesian carp will enable the grass carp to compete equally for food. One of the most important factors which should be considered in this farming system is the capability of the farm family to manage efficiently the tricommodity enterprise.

CONSTRAINTS AND SOLUTIONS

1. Lack of technical know-how

Farmers normally lack basic knowledge on livestock rearing, fish culture and vegetable or crop growing. The government should be able to provide enough training facilities for the farmers, to enable them to overcome this problem. At present, there are several centers which conduct training for farmers in livestock, fish and crop production, however what is needed is a coordinated program of training which should include in the curriculum the principle and methods of integrated farming and methods of recycling farm resources.

The extension workers should also be trained in the various aspects of integrated farming.

2. The need for a coordinated extension service

In Malaysia matters related to livestock, crops and fisheries are managed by separate agencies although they are under the same Ministry (crop is under the Department of Agriculture; the Department of Veterinary services deals with livestock, and the Fisheries Department is responsible for inland fisheries). Thus, the success of this program will depend greatly on the ability of these three agencies to coordinate their efforts in so far as integrated farming is concerned.

3. Seed supply

Adequate supply of seeds is prerequisite for any farming program. The government should expand the facilities to meet the demand for livestock, fish and crop seeds. These should include increased seed production, imports where applicable, improved distribution facilities and other related services.

The Fisheries Department still depends upon imports from Hongkong and Taiwan for its supply of chinese carps fry. The Department must intensify its efforts to produce seeds through induced breeding techniques.

At present the Fisheries Department is embarking on an induced breeding program for Chinese carps. Initially, two of the six fish Breeding Stations will be actively involved in this program. In addition, the government is constructing several Fish Breeding Stations and *Macrobrachium* hatcheries to meet the demands for seeds

4. Proper incentives for the farmers

To ensure the success of this program, the role of the government should be emphasized. A smallholder farmer needs proper guidance and encouragement. He also needs capital to adopt the new technologies extended. Adequate incentives should be given to him. These incentives could include market guarantee for his farm products, fair price and financial support from the government, such as subsidies and better credit facilities.

To achieve the desired objective, the extension service system should be adequate both in terms of credibility and staff strength.

REFERENCES

1. Ang, Kok Jee. 1978. Some Aspects of Fish Culture and Animal Husbandry in Malaysia. Animal conference of Malaysian Veterinarian Association, Kuala Lumpur. Seminar paper.
2. Hutagalung, R. I. 1978. Role of nutrition in livestock production. Technology for Rural Development Seminar. Seminar paper.
3. Inland Fisheries Monthly Statistics, Fisheries Department Malaysia, April 1979.
4. La Mare. 1952. Pig rearing, fish farming and vegetable growing. Malaysian Agr. Jour. Vol. XXX (3) 156–166.
5. Leong, E. S. L., C. Davendra, Y. H. C. Hong. 1976. Animal Proteins: Their avilability and future demands for human consumption in Peninsular Malaysia. Minsitry of Agriculture and Rural Development.
6. Ministry of Agriculture. 1979. Recommendations for National Agricultural Policy, Malaysia.
7. Sir, A. W. and K. W. T. Cheng. 1976. Management Systems of Inland Fish Culture in Hongkong. Indo-Pacific Fisheries Council Proc. 17th Session, Colombo, Sri Langka Symposium on the Development and Utilization of Inland Fishery Resources.

Appendix I

Existing and potential areas for freshwater fish culture in Peninsular Malaysia
(March, 1979)

State	Number of fish farmers					No. of ponds in operation	Acreage of ponds in acres	Potential areas estimated in acres
	Malay	Chinese	India	Others	Total			
Perlis	24	3	—	8	35	41	18.11	200
Kedah	193	23	—	20	236	458	261.18	30,200
Penang	25	30	1	21	77	135	42.55	120
Perak	1,511	1,293	61	48	2,913	4,226	8,120.89	22,000
Selangor	219	213	13	84	529	955	924.85	1,800
Negeri Sembilan	1,409	308	12	15	1,744	2,486	910.04	1,300
Melaka	189	67	3	5	264	422	152.81	350
Johor	381	309	1	17	708	1,448	585.53	700
Pahang	955	133	6	28	1,122	1,453	892.95	750
Trengganu	227	6	—	—	233	295	125.96	1,300
Kelantan	239	8	—	—	247	259	115.44	1,600
Total	5,372	2,393	97	246	8,108	12,079	12,150.31	60,320

1 acre is approximately 0.406 hectare
Monthly Inland Fisheries Statistics, Fisheries Division, Ministry of Agriculture, Malaysia, 1979

Appendix II

Proposed areas to be developed for tricommunity integrated farming in Malaysia

Items	Areas available for fish culture (ha)	Areas to be developed for integrated farming (ha)			
		fish-chicken-crop	fish-duck-crop	fish-pig-crop	Total
Existing areas (ha)	4 800	1,600	400	400	2,400
Potential areas (ha)	24,300	8,100	2,025	2,025	12,150
Total	29,100	9,700	2,425	2,425	14,550

Appendix III

Projected available area under animal-cum-fish culture by 1990

Year	Total pond area (AC)	Area for mixed farming (AC)[1]	Area for ponds with poultry (AC)[2]	With duck (AC)[3]	With pigs (AC)[4]
1976	11,263*	—	—	—	—
1977—1980	13,263*	6631.5	4421.0	1105.3	1105.3
1980—1985	15,764*	7882.0	5254.7	1313.7	1313.7
1986—1990	18,264*	9132.0	6088.0	1522.0	1522.0

1 It is assumed that with government encouragement and publicity, at least half of the pond owners will take up mixed farming under animal cum fish culture.

2 Two third of the pond area under mixed farming is recommended for chicken and fish culture.

3–4 The remaining areas are divided equally between ducks and pig-cum-fish culture.

* The increase in pond area is calculated on the basis of an annual increase of 500 ac. based on the average increase from the year 1972 to 1976.

Note: Appendixes III, IIIa, IIIb, IIIc are extracted from recommendations for Malaysian National Agricultural Policy.

Appendix IIIa

Number of chicken required, expected production by years

Year	Available pond area (AC)	No. of chicken required	Expected production (Metric tons)	No. of fish	Fish production (Metric tons)
1977—1980	4421	442100	750	A. 22,105,000 B. 442,100 C. 530,520 D. 1,105,250	2105
2 crops/year		884200	1500	A. 44,205,000 B. 884,200 C. 530,520 D. 1,105,250	12631.6
1981—1985	5254.7	525470	891	A. 26,273,500 B. 525,470 C. 630,564 D. 1,313,675	2502
2 crops/year		1050940	1782	A. 52,547,000 B. 1,050,940 C. 1,261,129 D. 2,627,350	5004
1986—1990	6088.0	608800	1033	A. 30,440,000 B. 608,800 C. 730,560 D. 1,522,000	2899
2 crops/year		1217600	2066	A. 60,880,000 B. 1,217,600 C. 1,461,120 D. 3,044,000	5798

Appendix IIIb

Fish-cum-duck culture in terms of areas available, number of duck, expected production by years

Year	Areas Available (AC)	No. of duck	Duck expected production (Metric tons)	No. of fish	Fish expected production
1977—1980	1105.3	110,530	187.5	A. 55,265,000	526.3
				B. 110,530	
				C. 132,636	
				D. 276,325	
2 crops/year		221,060	375.0	A. 11,053,000	1053.0
				B. 221,060	
				C. 265,272	
				D. 552,650	
1981—1985	1313.7	131,310	222.9	A. 6,568,500	625.6
				B. 131,370	
				C. 157,644	
				D. 328,425	
2 crops/year		262,740	445.7	A. 13,137,000	1251.1
				B. 262,740	
				C. 315,288	
				D. 656,850	
1986—1990	1522.0	152,220	258.2	A. 7,610,000	724.8
				B. 152,200	
				C. 182,640	
				D. 380,500	
2 crops/year		304,400	516.9	A. 15,220,000	1449.5
				B. 304,400	
				C. 365,280	
				D. 761,000	

Appendix IIIc

Fish-cum-pig culture in terms of areas available, number of pigs and fish, and estimated production by years

Year	Areas available (AC)	No. of pigs	Estimated production (tons)	No. of fish		Estimated production (MT)
1977–1980	1105.3	13263	1026.4	A.	55,265	526.3
				B.	221,060	
				C.	110,530	
				D.	552,650	
2 crops/year		26526	2052.7	A.	110,530	1052.7
				B.	442,120	
				C.	221,060	
				D.	1,105,300	
1981–1985	1313.7	15764	1220	A.	65,685	625.6
				B.	262,740	
				C.	131,370	
				D.	656,850	
2 crops/year		31528	2440	A.	131,370	1251.1
				B.	525,480	
				C.	262,740	
				D.	1,313,700	
1986–1990	1522	18264	1413.3	A.	76,100	724.8
				B.	304,400	
				C.	152,200	
				D.	761,000	
2 crops/year		36528	2827	A.	152,200	1450
				B.	608,800	
				C.	304,400	
				D.	1,522,000	

Appendix IV

Integrated farming

Fish-cum-livestock, Malaysia, 1979

State	Number and acreage of ponds										Total				Fish species
	Fish/cattle		Fish/pig		Fish/poultry		Fish/duck		Others						
	No.	Acreage	No.	Acreage	No.	Acreage	No.	Acreage	No.	Acreage	No. of ponds	Acreage	No. of animals	No. of farmers	
Perlis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Kedah	—	—	—	—	—	—	3	1.23	—	—	3	1.23	100	1	*Puntius gonionotus,*
Pulau Pinang	5	2.37	10	3.38	—	—	—	—	—	—	15	5.75	1,980	6	*Cyprinus Carpio,*
Perak	19	11.35	34	50.63	30	6.22	4	2.14	—	—	87	70.34	7,388	23	*Ctenopharyngodon*
Selangor	7	8.00	—	—	1	1.50	—	—	14	9.13	22	18.63	1,875	3	*idellus* and
N. Sembilan	8	5.19	1	0.75	5	3.15	—	—	—	—	14	9.09	535	9	*Aristichthys nobilis.*
Melaka	—	—	—	—	—	—	—	—	—	—	—	—	—	—	— do —
Johor	9	9.00	7	3.75	—	—	27	27.00	—	—	43	39.75	178	5	— do —
Pahang	21	9.04	—	—	4	0.28	5	5.35	1	0.52	31	15.19	349	10	— do —
Trengganu	—	—	—	—	4	1.27	18	4.86	—	—	22	6.13	2,250	11	— do —
Kelantan	—	—	—	—	—	—	—	—	—	—	—	—	—	—	— do —
Total	69	44.95	52	58.51	44	12.42	57	40.58	15	0.65	237	116.11	14,655	68	— do —

Note: 1 acre = 0.405 hectare.

Appendix V

Imports of Feedstuffs into Malaysia
1970—1976

Commodities	1970		1971		1972		1973		1974		1975		1976	
—	Quantity*	Value**	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Maize unmilled	111.6	23.3	114.8	22.2	122.4	23.0	128.7	33.1	151.9	53.0	166.2	58.7	137.7	46.6
Maize for animal feeding	71.3	13.7	73.5	13.3	66.8	12.1	74.8	16.7	64.7	18.7	82.9	26.4	96.8	32.2
Copra cake	14.6	2.3	7.10	2.5	20.1	2.9	4.2	0.7	7.3	1.6	13.7	2.7	19.2	4.3
Groundnut cake	8.9	2.7	1.4	3.3	12.8	3.8	13.3	6.3	12.1	5.9	16.5	6.6	13.5	5.2
Rice bran	52.8	8.0	65.0	8.2	66.7	8.6	61.8	9.9	95.9	19.0	97.3	20.1	108.8	23.6
Prawn dust	3.7	6.1	1.8	0.2	1.8	0.2	1.6	0.2	0.8	0.1	0.6	0.09	0.2	0.03
Meat meal	8.8	3.4	10.4	3.6	12.4	4.1	5.3	3.7	8.4	5.2	19.1	8.1	11.4	6.0
Fish meal	11.5	5.1	9.6	4.1	10.2	4.7	4.3	2.2	2.8	2.6	10.1	6.0	9.1	5.4
Cassava refuse	7.3	0.9	6.8	8.6	6.1	0.7	3.6	0.5	11.9	1.9	4.9	0.8	1.8	0.2
Sago refuse	0.04	0.004	0.003	0.02	0.0002	—	—	—	—	—	—	—	—	—
Oats, unmilled	5.0	1.1	3.8	6.8	4.0	0.7	4.0	1.4	4.8	1.7	2.8	1.0	4.6	1.7
Milk, skimmed	4.7	2.8	3.0	1.9	2.1	2.5	1.5	2.1	1.2	2.0	4.1	6.0	10.2	10.4
Total	300.34	69.4	16.63	74.7	325.42	63.3	303.10	76.8	362.8	11'.7	418.2	135.5	413.3	135.6

Source: Statistical Digest 1970–1977
* in metric tons (10^3).
** 10^6 Malaysian ringgit.
Extracted from: 'Role of nutrition in livestock production' R.I. Hutagalung, Technology for rural development seminar, Malaysia 1978.

Appendix VI

Biological recycling principle

The biological recycling principle in tricommodity integrated farming may be illustrated in the following way:

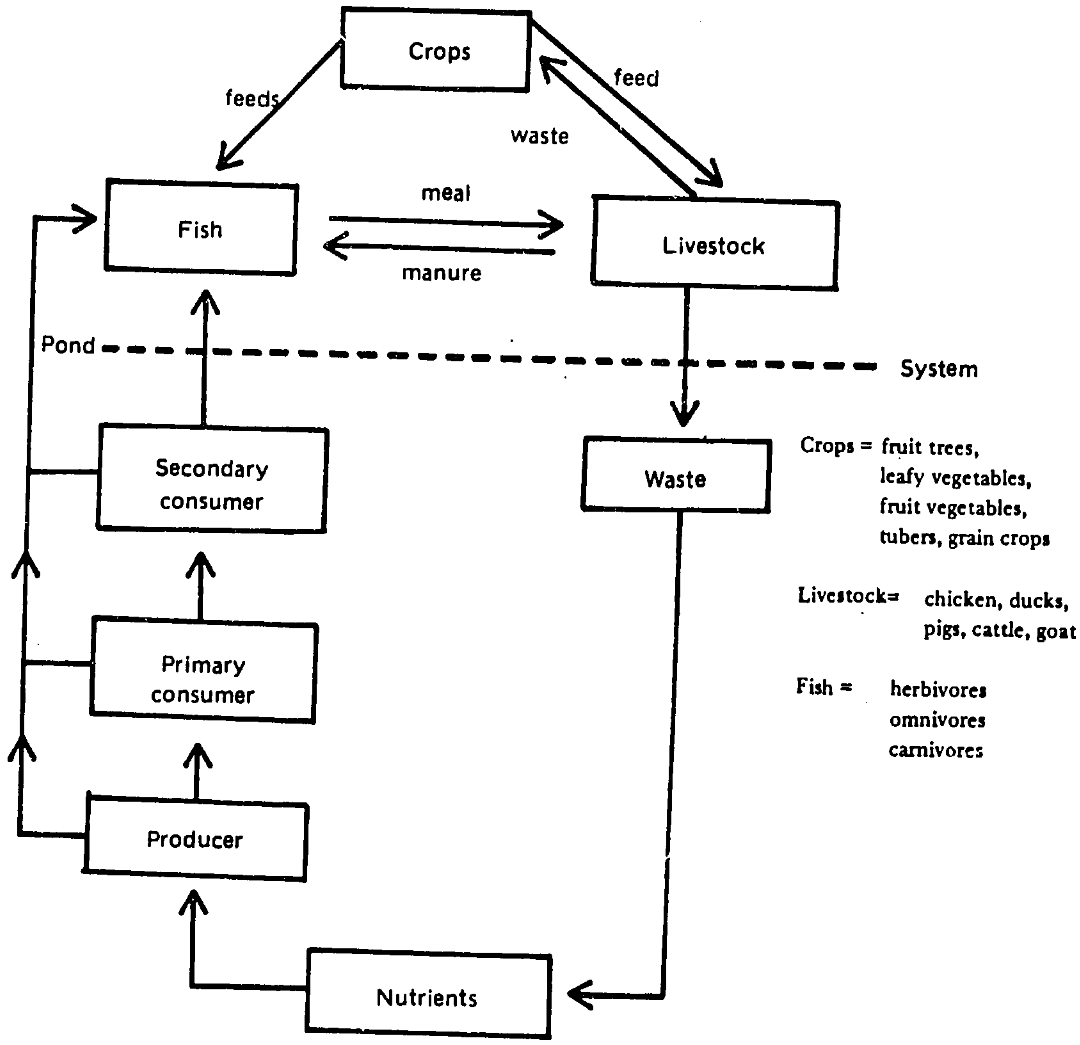


Fig. 1. Simplified diagram of recycling principle in tricommodity integrated farming

Note:

i. Whole or parts of crops may be used directly or converted to feeds for livestock such as chicken, ducks, cattle and pigs. The vegetative parts of crops may also be used as feed for fish especially for herbivorous fishes like grass carp and Indonesian carp.

ii. The wastes or washings from livestock may be used to fertilize both fish ponds and crops

iii. Fish meals may also be used as an additional source of protein for the livestock

iv. The waste from livestock decomposes to release mineral nutrients which will enter into the cycle of producers (phytoplanktons), primary consumers (zooplankton and some invertebrates) and secondary consumers (small invertebrates and some fish).

SARAWAK INLAND FISHERIES AND AQUACULTURE DEVELOPMENT PROGRAM ON INTEGRATED FARMING

by

Ong Kee Bian

INTRODUCTION

The Inland Fisheries and Aquaculture Development Scheme in Sarawak, Malaysia was initiated mainly for self-sufficiency in fish for the rural population. Most of the local rivers have been depleted of natural fish resource due to destructive fishing with tuba (rotenone).

Farmers were encouraged to establish fish ponds through the Fish Pond Subsidy Scheme and join the Inland Fisheries and Aquaculture training program. This scheme has enabled rural farmers to derive extra cash income and has helped to improve the efficiency of utilization of farmland not suitable for crops for fish ponds. Integrated fish-livestock-crop farming was demonstrated and encouraged wherever suitable to increase fish yield from pond and productivity of the farm unit.

Extension services are provided through the inland fisheries extension staff stationed at the divisional/district administration offices. There are to-date 15 inland fisheries stations, 8 coastal aquaculture stations and 15 fry holding/distribution units. The program provides fish farmers with stocking materials of several species of fish and prawn which are given free. The prawn species distributed free is *Macrobrachium rosenbergii* and the fish species include *Cyprinus carpio, Tilapia nilotica, Tilapia zillii, Puntius gonionotus, Puntius orphoides, Trichogaster pectoralis, Helostoma temmincki, Osphronemus gouramy* and *Carassius auratus*.

In addition, farmers who provide the recommended type of tanks are given young freshwater soft-shelled turtles (*Amydas sonensis*) and the young American bullfrogs.

Besides the above stocking materials, the required materials such as pipes, wire-netting for screens, cement for the sluice-gates or spillway and required lime and fertilizer are also supplied free under the Fish Pond Subsidy Scheme.

TRAINING PROGRAM

Four types of inland fisheries and aquaculture training courses are conducted for the inland fisheries station and extension staff, husbandry teachers, commercial pond-keepers, farmers/fishermen and school dropouts. There are:

1. Freshwater aquaculture (1 month and 2 weeks)
2. Aquarium fish keeping (2 weeks)
3. Coastal aquaculture (2 weeks)
4. Lake and riverines fisheries (2 weeks)

RESEARCH AND EXPERIMENTAL STUDIES

In addition to the varicus stations that produce and distribute stocking materials and conduct inland fisheries and aquaculture training courses, there are stations carrying out research and experimental studies. These studies are aimed to generate new techniques and improve on existing practices for controlled breeding, fry production (collection) and aquaculture for selected aquatic species aiming to improve the production and stock quality.

In the diversification aquaculture scheme, a number of finfish, crustaceans, mollusks, and other species are being experimented on. Encouraging results with respect to technology development/ improvement have been obtained with finfish, prawns, frog and turtles. The production of fry under controlled conditions has been successful with the giant freshwater prawn, the introduced fish, the pearlspot and experimentally successful with marine prawns. Efficient techniques for fry collection have been developed for finfish, mullet and marine prawns. The economical feasibility on cage culture for grouper, seabass, and commercially important indigenous fish is being tried on small farms as well as on a large commercial farm with the main crop being either fish, livestock or fruit and vegetable crops. There are many poultry farms today with crocodile ponds which utilize the dead chicken.

Large commercial fish farms have found it profitable to include livestock especially poultry shed over their production ponds to improve the pond bottom soil and water condition at little cost instead of purchasing fertilizer. Where fruit trees and vegetables are grown along the pond bunds, the silt from the pond bottom provides good manure for the crops. The sitting of small units of poultry shed over the fish ponds has proved of great advantage to rural fish production. Beside the spill-over poultry mash to feed the fish, the chicken droppings enrich the pond bottom soil to promote growth of organism for the bottom feeding fish like the common carp. The added nutrients in the water stimulate the growth of phytoplankton for the mid-water feeding fish especially the Silvercarp and Bighead carp, which are also issued free to the farmers in addition to the suitable species of locally bred fish. The surface feeders such as the grasscarp, giant gouramy and Javanese carp are fed with tapioca leaves, cut grass and other soft leaves of *Calocassia* and *Ipomea* grown in the farm.

CONCLUSION

The simple system of tricommodity integrated rural farming in Sarawak has been fairly successful. Joint effort of Inland Fisheries and Agricultural Extension staff in the State is maintained. A booklet on 'Fish Culture' in Sarawak was prepared by the author as a guide for the Inland Fisheries Station and extension staff.

The next phase of the development is to encourage the private sector to establish commercial aquaculture farms to provide the necessary services, such as production of stocking materials to meet the current and future demand of the many small scale fish farmers.

The State Inland Fisheries and Aquaculture Development is engaged in development of lake and riverine fisheries whereby the floating cage culture system is introduced to areas with regular flood problems such as in the Baram District. This development program also includes controlled breeding of commercially important indigenous fish for supply of fry to the various culture systems and restocking of the lakes and rivers. With this, we hope to increase the source of animal protein for the growing population, as well as the cash income for the fish farmers.

MAYA FARMING SYSTEM

by

F. D. Maramba, Sr.

INTRODUCTION

In experiments conducted in the early 1950s by the Land Settlement and Development Corporation (LASEDECO), it was found that at least seven hectares are needed for sufficient income and decent standard of living of a farm family. However, most of farms distributed under Land Reform were less than 2.5 hectares (between 1.0 to 2.5 ha). With the traditional systems of farming, these are not adequate to provide a reasonably comfortable life for the farm family.

The 'Maya Farming System' proposes to improve the situation in the following manner:

1. In a crop farm, the farmer works only in the early morning and late in the afternoon, to avoid the heat of the sun. He is idle some months of the year as he waits for the planting season; after planting he again waits for the harvesting season. Hence he is underemployed. The same is true with a livestock farmer or a fish farmer. An underemployed farmer cannot possibly earn a good income. Studies at Maya Farms show that integrating crop, livestock and fish farming in a correct balance will fully employ the farm family.

2. The crop farmer produces feeds which he sells to the livestock farmer. Integrating the two farms avoids the cost of transportation, financing and profit of middlemen.

3. In most farms, yields are low. But there are varieties of crops and breeds of livestock and fish that give high yields if properly selected and cared for. The farmer can easily take advantage of these varieties.

4. The present farm practices are wasteful. Studies have shown that these wastes can be converted into the very inputs (fuel, feed and fertilizer) which farmers buy at high prices.

DESIGN OF AN INTEGRATED CROP-LIVESTOCK FISH FARM

Maya Farms, an integrated crop-livestock, fish, meat processing and canning enterprise has successfully experimented on the tricommodity integration. In December 1978, it started with this project on a 1.2 hectare family farm operated by an independent farmer. An accounting made on October 13, 1979 revealed that the farmer had earned ₱ 16,000 after subtracting his family expenses, and he has been living more comfortably than the ordinary farmer.

The result was so convincing that Maya Farms has been offered ₱ 4 million to be used to duplicate these results in land reform areas in different parts of the country. In this project Land Reform awardees of 1.0 to 2.5 ha crop farmers will be converted into integrated crop-livestock-fish farms. The necessary capital to be provided the farmers will be paid back without interest from income from the livestock. It is expected that the farmer will liquidate his account in three years, and that he will have a net income of ₱ 15,000 to ₱ 20,000 every year, after food expenses.

The integrated crop-livestock fish farm is designed to:

1. produce enough nutritious well-balanced food for the growing population
2. attain farm self-sufficiency as much as possible
3. provide full employment for the farm family throughout the year
4. attain increased profitability in farming.

These objectives are accomplished by:

1. integrating crop-livestock-fish farming to increase the farm activities in such a way as to keep the farm family busy all day long, throughout the year
2. increasing crop production by multiple cropping, thus keeping the land in cultivation all year round
3. raising livestock that would feed on the farm products and by-products
4. converting the farm wastes into useful products and control pollution through biogas works.

In the Maya Farming System, the farmland is allocated as follows:

	1.2 ha		7.0 ha	
	Irrigated	Rainfed	Irrigated	Rainfed
Cropland	1.00	1.00	6.00	6.60
Fishpond	0.02	–	0.60	–
Ipil-ipil grove	0.10	0.12	–	–
Livestock and biogas works	0.02	0.02	0.15	0.15
Home lot	0.03	0.03	0.10	0.10
Roads and pathways and canals	0.03	0.03	0.15	0.15

Cropping System

In the irrigated farms, two crops of rice and one crop of corn are planted in a year. Eight plots are prepared and planted successively at one week intervals. Usually rice planting starts in June (see Chart I). As soon as the first rice crop is harvested in the second week of October, the plot is again prepared and planted to rice. This is succeeded by the other plots every week until all the plots are planted. After the harvest of the second crop of rice, corn is planted successively in the same manner.

The rice crop requires 19 weeks and corn 14 weeks. Hence, two crops of rice and one crop of corn would require 52 weeks. This way, the land is continuously cultivated, land preparation is simplified and energy requirements are materially reduced.

In the rainfed farms two crops of corn and one crop of rice are planted (Chart ?). The first crop of corn is planted in mid-April, every week successively, until the three plots are planted. The rice crop is planted after the corn harvest and the second crop of corn is planted after the rice. It should be noted that in this way the land is vacant for about 5 weeks

Chart 1 Irrigated Farm Culture

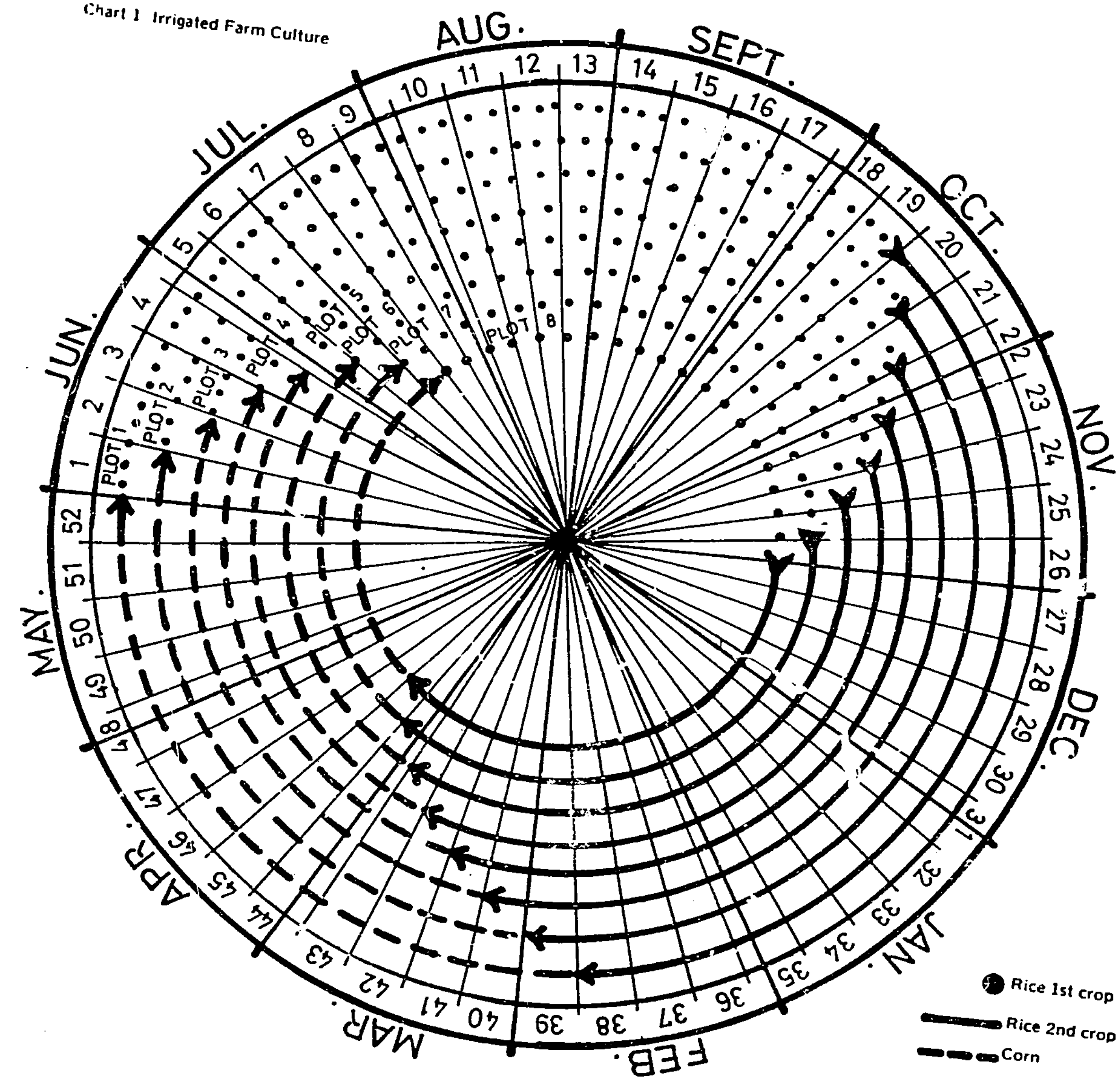
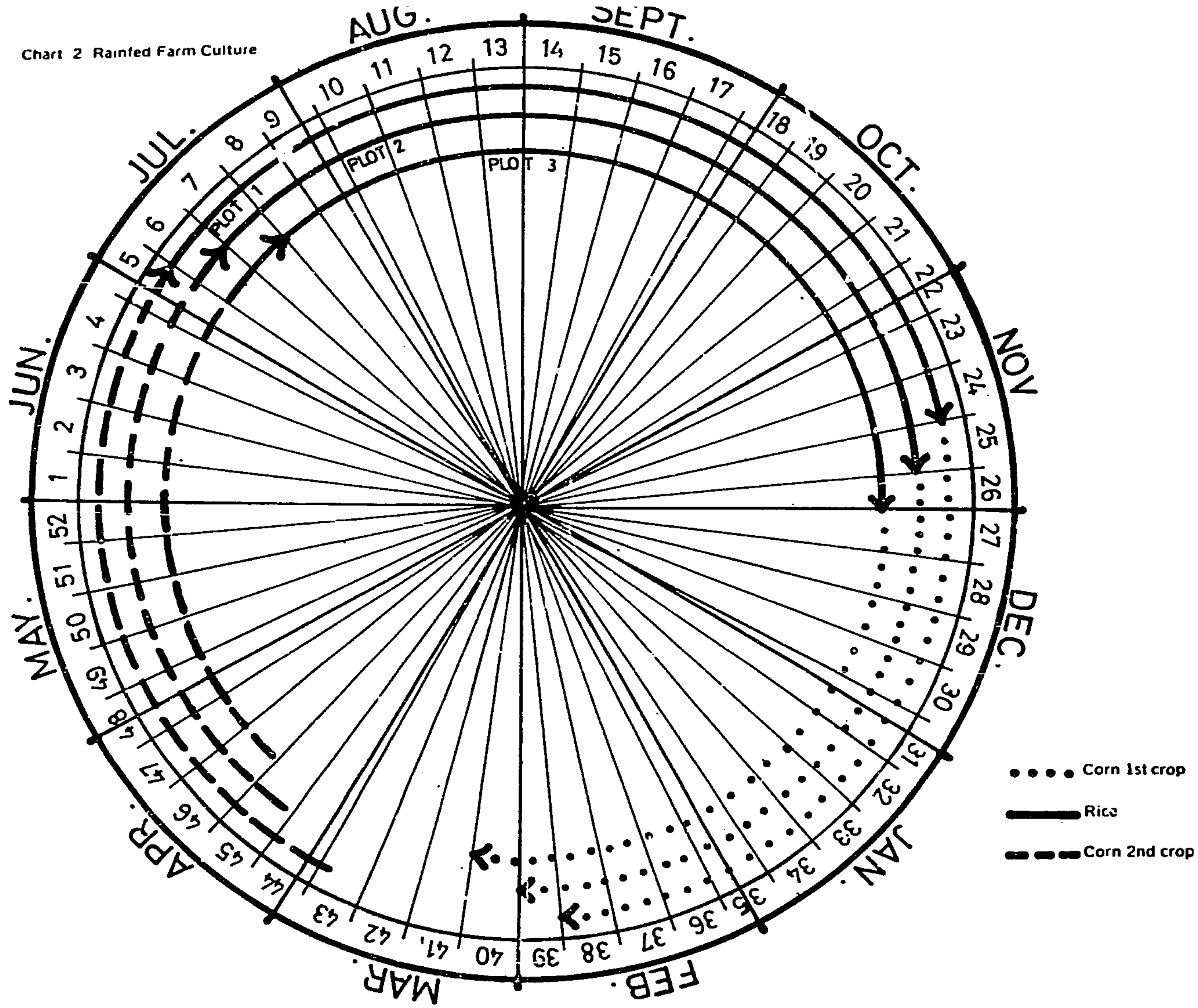


Chart 2 Rainfed Farm Culture



Cultural Requirements

The following are the steps to follow in rice culture:

1. Cut the corn stalks close to the ground
2. Apply compost
3. Soak the soil thoroughly (do not flood) for about 3 days
4. Flood the paddy with 6 inches of water for 5 days
5. Drain the paddy to 3–4 inches deep
6. Rotovate with drag harrow pulled by carabao or by walking tractor with arowheel attachement
7. Flood paddy to 4 inches deep
8. Prepare 'dapog' seedlings
9. Three to five days after the last flooding, pass peg-tooth harrow along and across the rows
10. Flood about 4 inches deep for 3–4 days
11. Drain to 2 inches deep
12. Level by 'suyod' (animal-drawn harrow)
13. Transplant seedlings (10–12 days old)
14. Irrigate progressively following the growth of the seedlings
15. Weed every 3 weeks
16. Twenty days before harvest, start draining the paddy
17. Five days before harvest, the paddy must be free from water
18. Harvest by scythe close to the ground
19. Thresh the harvest
20. Dry the palay

In the 1.2 ha farmland, only working animal power is required. As stated above, the 7.0 ha farm would need mechanical power except for the levelling of the field which is done with 'suyod' pulled by carabao. This system of land preparation would cut energy requirements by about 30%.

The sequence of operation for corn are:

1. Furrow the field
2. Plant the corn immediately
3. Irrigate
4. Weed every three weeks
5. When the corn cob is already filled with grains, start removing the leaves and feed to the carabao
6. After harvesting the corn, cut the corn stalks close to the ground.

In the corn crop culture, all land preparation is eliminated except the furrowing of the field. With continuous cropping, only one land preparation is needed which is done before rice planting. By pulling the weeds instead of plowing them under, the field will relatively be cleaner at the time of harvest; hence there will be no need of plowing and harrowing the fields before planting corn. This system will reduce power requirements to only about 20% of what is usually required.

Weeding is done every three weeks by pulling the weeds including the roots. The roots are cut off and the leaves are used as feed for the carabao. It was found that allowing the weeds to grow for three weeks will not adversely affect the yield of the crop. When the corn ear is filled, the leaves are fed to the carabao.

Piggery

The piggery is raised from the original one sow unit in the farm to the size necessary for recycling, which is, four sow units for a 1.2-ha farm and 24 sow units for the 7-ha farm. Assumed production is 2 litters per sow per year, giving 10 porkers and 6 breeding gilts per sow per year. The porkers are sold at 7–8 months old, with an average weight of 80 kilos per head.

Cattle

The number of cattle to be raised depends on the area of cropland in the farm. It has been found that the weeds and crop residues from one hectare, and leaves from 1000 m^2 of giant ipil-ipil (*Leucaena leucocephala*) will provide all the forage needed by three large animals. Therefore three head of cattle could be raised for every hectare of cropland. The cows are used to produce milk and the steers are for beef.

Ducks

There shall be as many ducks as the number of pigs plus 5 times as many as the number of cattle. The excess breeding ducks are sold after they are 6 months old. The drakes are sold for meat.

Fish

The size of the fish pond depends on the amount of water available. Rainfed areas may not have sufficient water to maintain a fishpond. Liquid sludge from the biogas works is used to fertilize the growth of algae which serves as food for the fish. The shell fish for duck feed is raised in the fish pond.

Biogas Works

Manure is used as raw material for the biogas works. In small farms the biogas produced is used to cook the meals, light their home, iron their clothes and operate a gas refrigerator. In large farms, there will be enough biogas to pump water, grind and mix the feed, run an electric generator, etc. In large stock farms, only 40% of the biogas is needed on the farm. The rest can be used to light a neighboring barrio and/or small industry.

The solid sludge is processed into feed material rich in the growth-promoting vitamin B12. This constitutes ?0% of the pig feed, 10% of the cattle feed and 50% of the duck feed. The liquid sludge flows to the irrigation ditch to fertilize the crops in place of chemical fertilizer. The overflow from the rice field is used to fertilize fish ponds to grow algae and zoo-plankton to feed the fish.

The Ranch

The allocation of one hectare pasture per head of cattle in a ranch is based on the capability of the pasture to grow enough forage during the dry season. During the rainy season, there will be more forage than is needed by the cattle. But usually a large portion of the ranch is eroded and/or too steep for pasture, so it is grown to trees to serve as windbreak and shed. Tests show that ipil-ipil leaves can be used as feed for cattle to the extent of 20% for breeding animals and 30% for finishing. Maya Farms found that these areas may be replanted to giant ipil-ipil. The leaves are fed to cattle during the dry season when there is not enough forage. The trunks are made into charcoal for gas producer for power needs.

There are numerous creeks in the ranch which may be dammed to serve as fish ponds. Manure in the night canal may be collected to produce biogas which may be used as fuel for pumping the excess water for irrigating part of the pasture.

DISCUSSION

Q. Sludge or effluents from biogas in initial stages of experiments contained toxic substances; with the use of detoxication process the effluents can be made beneficial. How do you do this?

A. The toxic substance is hydrogen sulfide; exposure to sunlight and aeration eliminate this substance. First, the effluents were aerated by bubbling compressed air; later we used water wheel run by windmill. But when we had ducks, they did all the aeration.

Q. What is your total pond area and how many kilograms of sludge/manure used? What is the fish production?

A. One sow unit of pig will eat 15 kilos of standard feed – 10% of this has been replaced by solid sludge. We have one hectare of pond, but we cannot expand because of shortage of water. We are now experimenting on catfish which can survive without dilution of water. In a 250 m^2 fish pond, after 4 months of seeding, we harvest 3 kilos of tilapia every week; 5 liters of liquid sludge is added every week. When it is too green, we add water and make it overflow.

DEVELOPMENT OF REGIONAL COMPLEX UPLAND FARMING—TWO SUCCESSFUL CASES IN HOKKAIDO, JAPAN

by

Tadashi Tenma

INTRODUCTION

Presently, agriculture in Hokkaido is in the era of systematized regional farming. The inherent tendency towards the development of monotype large-scale farms which deviate from the diversified type seems inevitable because farmers have long been seeking for scale merit, which stems from farm specialization. Farmers are aware of the scale merit not only for its economic benefits which are more than that obtained from crop diversification but also of other factors. Several factors have been instrumental in the establishment of simplified large-scale commercial farms in Hokkaido. These factors include the effects of the exodus of large number of farmers since 1960, the beginning of the country's economic growth and prosperity; extension of mechanized farming; wide enactments of government policies for subsidy, crop insurance, and price stabilization system and; the rise of various types of farmers' cooperative organizations.

The transition from the small-scale diversified farms to commercial farms with large-scale specialized enterprises has had a strong impact on the country's regional farming. First, it led to the regional recycling of animal wastes to balance the over-and under-supply of organic materials among each individual farm in a certain area. Second, it has motivated the establishment of various farmers' cooperatives which helped solve the labor shortage in farms and prevented over-investment in farm machinery and other equipment. Third, it promoted the industrialization of regional farming which fulfilled the farmers' desire to process their own farm produce for higher profits.

The two cases presented here are good examples of farming which had led to successful regional specialization through recycling of animal manure and effluents from the processing factories to maintain soil fertility. One case shows the formation of cooperative groups to maximize the supply of farm labor and the use of farm equipment without individual over-investment; another shows the industrialization of agriculture through individual processing of farm produce at higher level for higher profits. These regional farms were initially faced with difficulties yet emerged successful paralleling or equalizing the modern and intensive farming in highly advanced industrialized countries.

CASE I. NAKASATSUNAI-MURA— A REGION WHICH AIMED TO SYSTEMATIZE FARMING THROUGH FARM COOPERATIVES

Nakasatsunai-mura, a relatively small village, is one of the 20 villages in the Tokachi Plains of Hokkaido. It has a population of 3,800 with 290 farms. The average landholding per farm is 22 hectares. The total tillable land area is 6,500 hectares which are planted to the following crops: beans–1,800 ha (27.7%), potatoes–1,000 ha (15.4%), sugar beets–900 ha (13.8%), wheat–400 ha (6.2%), and forage crops–2,200 ha (33.8%). The village is also famous for its livestock industry, with 450,000 broilers, 200,000 layers, 15,000 hogs, and 3,400 dairy cows.

In 1960, the people of the village organized cooperative farms to avoid the continuous exodus of farmers who seek jobs in the cities. At the start, meetings were held to discuss solutions to the perennial problem of the effects of cold weather on crops particularly beans, in some areas of the village, and the decision reached was to temporarily devote these areas to livestock. These series of meetings and discussions led to the formal creation of cooperative farms. The people cooperated in changing their types of farming from crop raising to livestock production. They put their money in the cooperative and the cooperative purchased all the machinery and equipment instead of individual members procuring them. This type of cooperative farm has about five member farms each, and approximately 120 family-type farms which are also actively taking part in various cooperative activities.

Systematized Farming Activities

Initially, the village was divided into three agricultural districts based on the previous experiences on agricultural output and the effects of severe cold weather on crops in certain areas.

To facilitate the rapid increase of both livestock and crop production, the cooperative set up the necessary facilities in each district. In Nakajima and Kamisatsunai which are areas devoted mainly for livestock, large machinery centers for forage crop production and community pastures, nursery centers for calves, cooling stations for milk, concentrate feed factory, and a rendering plant were installed. In Nakasatsunai district, a crop production area, large machinery centers for crop harvesting, drying facilities for wheat and beans, potato storage houses, nursery beds for sugar beets, and potato starch factory were established. The organizational set-up and agricultural structures in each district are summarized in Figure 1.

The cooperative in its early growth and expansion was beset with serious problems which almost offset the merits of specialized systematic farms. In the crop district, the cooperative was faced with problem of diseases and insects, farmers' strong reliance on commercial fertilizers, thus neglecting crop rotation, and water pollution. The fishermen particularly asked for immediate solution to pollution of rivers and other waterways by the potato factory. Furthermore, the fertility of the soil decreased, and crop resistance to weather conditions lowered resulting to poor harvests. In the livestock areas, the farmers depended too much on the expensive but readily available commercial concentrates in their attempt to increase livestock production. As a consequence, their income became considerably unstable because of fluctuations in the price of commercial feeds. In addition, the animal manure in big farms accumulated in large amounts which were more than the farms could use as fertilizers.

The leaders of the cooperative realized that to solve such tremendous problems would necessitate the organization of the three districts into one systematic production unit under the management of the agricultural cooperative. This was agreed upon to avoid individual problems in each district by working together in a complementary manner.

Recycling Farm System

The recycling farm system was created in 1972 as a result of the fusion. The agricultural cooperative built a lease-type poultry house which could accommodate 100,000 layers and subsequently leased it to five member farms. To utilize fully the collected amount of chicken dung of 4,000 tons annually, with the least cost, the cooperative designed the slurry system. By this method, the chicken dung is diluted with 40% water, fermented, and stored for sometime before it is applied in member farms. Through the slurry system, the cooperative was able to solve the large accumulations of chicken dung in each farm, and fully made use of it as effective fertilizer, thus avoided possible public criticism.

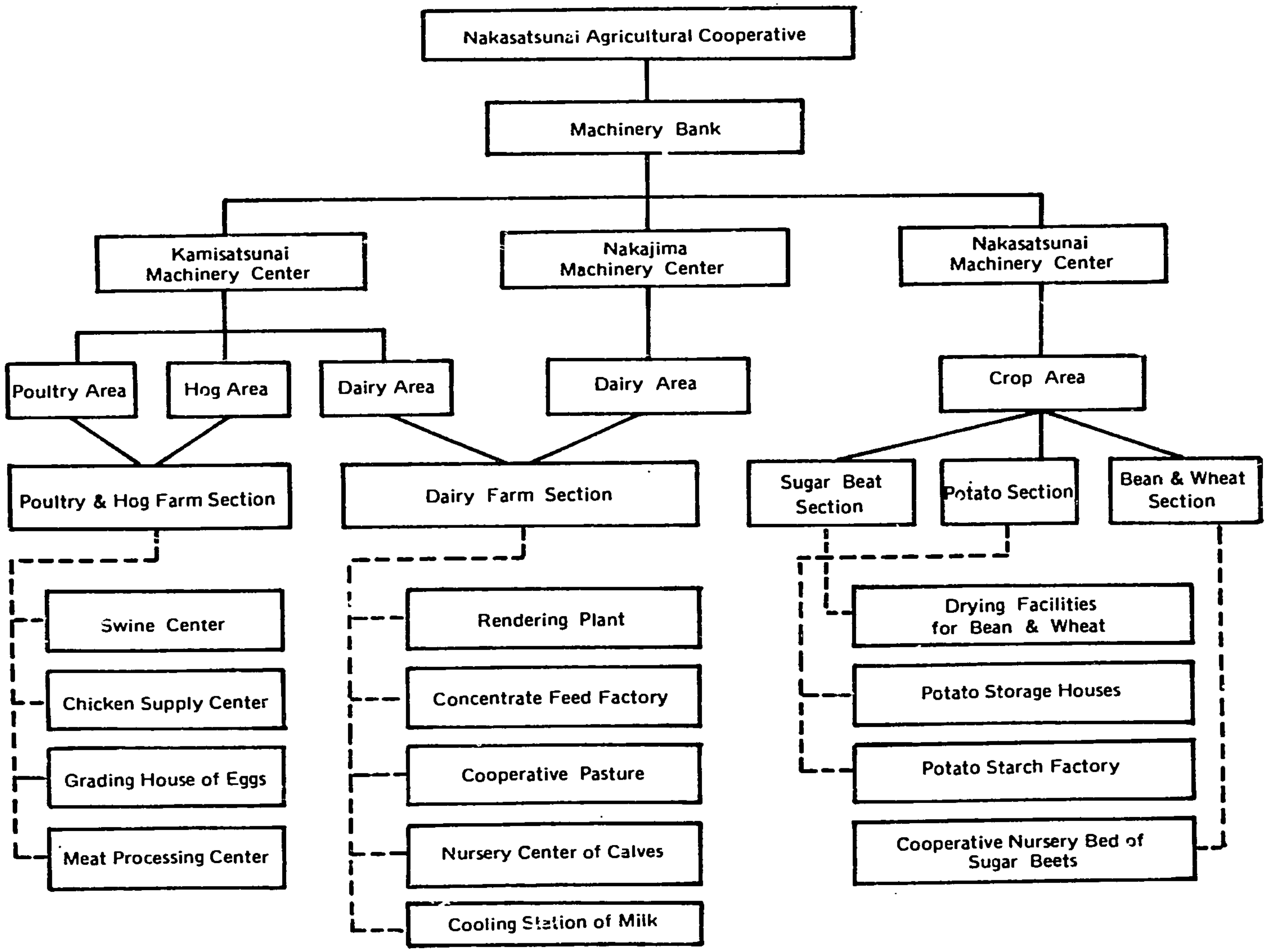


Figure 1 The agricultural structures in Nakasatsunai cooperative area

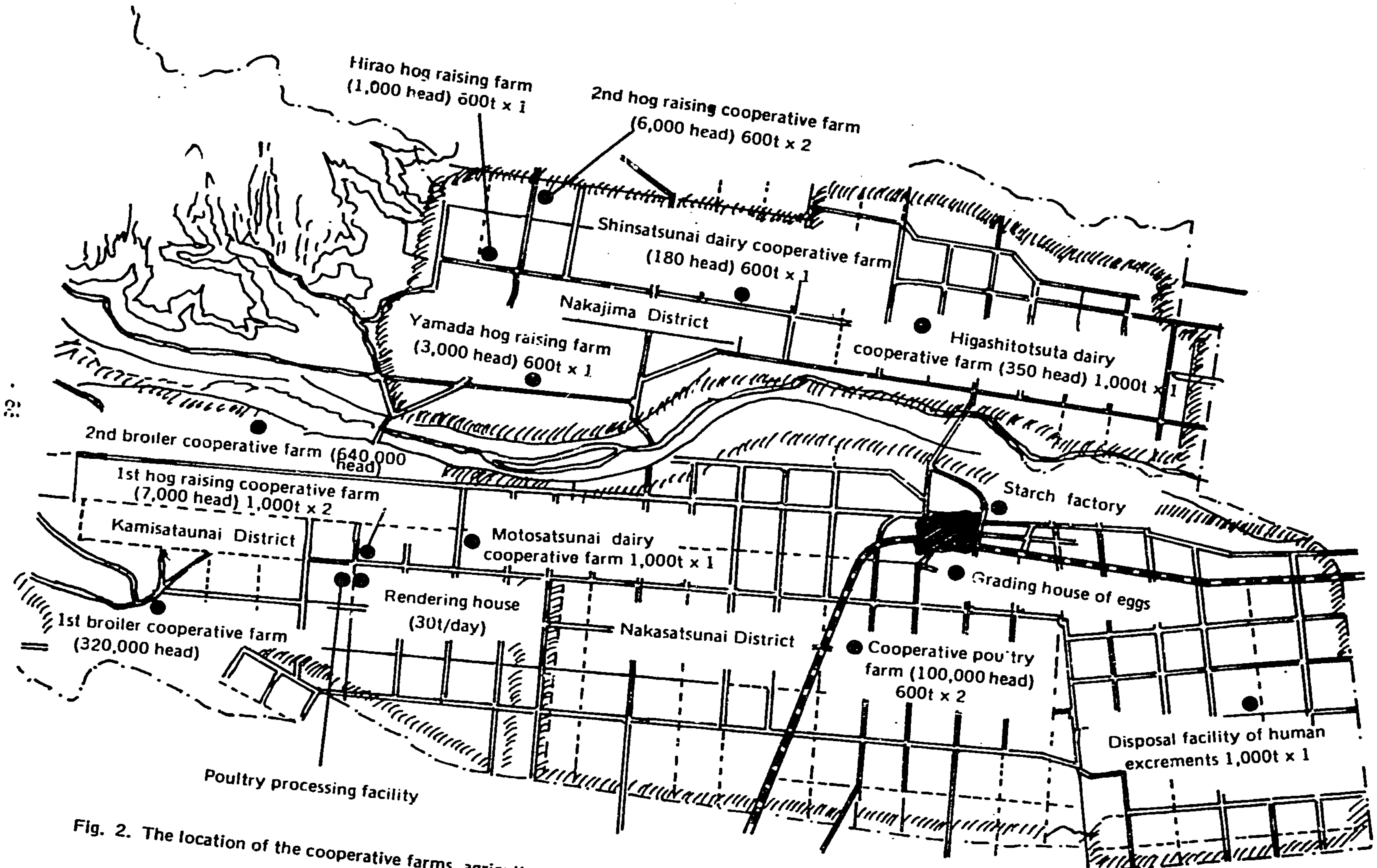


Fig. 2. The location of the cooperative farms, agricultural facilities, and the attached slurry system in the 3 districts of Nakasatsunai-mura

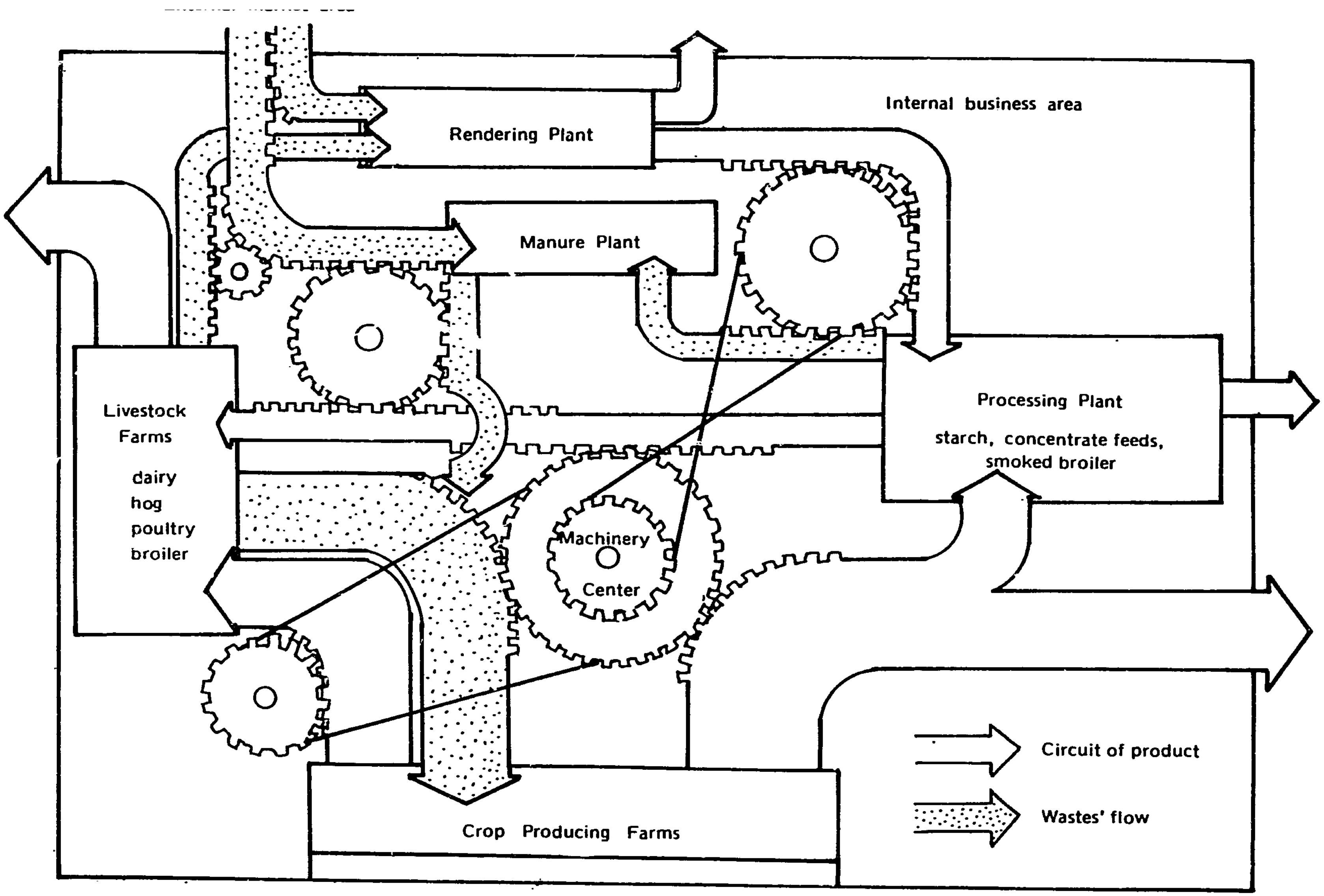


Figure 3. Circulation structure of produce and wastes in Nakasatsunai-mura

With the initial success in poultry raising and in handling the animal excreta, the cooperative then established two piggery farms with a capacity of 7,000 and 6,000 head each, and cooperative cow sheds. These farms were also leased to member farms. The cooperative made it a point that all the new livestock farms to be built should have provisions for the convenient and easy collection, storage and disposal of the animal manures through the slurry system. Several slurry systems were built in strategic locations of the village (Fig. 2).

The problem of efficient application of slurry materials has become so great that the cooperative finally created the farm machinery center. The center collects, ferments and stores animal wastes before they are applied in member farms which request for slurry materials. In Kamisatsunai alone, the center owns three vacuum trucks for collecting the animal manures, and one soil injector which applies the slurry materials underground in places where the foul odor can create public nuisance.

The farm machinery center buys chicken dung from farmers at ¥ 125 per ton (approximately US$0.57), and cattle and hog manure at ¥ 50 (US$0.23) per ton. In return, the center charges chicken slurry materials for ¥ 775 (US$3.5) per ton, and ¥ 700 (US$3.2) for cattle and hog slurry per ton, and an additional delivery and spraying cost of ¥ 650 (US$2.9).

The use of slurry materials has become so popular and effective that the cooperative later had the problem of slurry shortage. The cooperative solved this by constructing a special slurry tank where animal wastes are mixed with human excreta after proper treatment and disinfection of the latter.

In the late 1960s and early 1970s, the widespread concern over the pollution not only in Hokkaido posed another problem to the cooperative, particularly with the disposal of the factory sewage from the potato starch factory and rendering plant. A technique which was developed in Netherlands was adopted to solve this problem. The by-product potato dregs were converted into potato proteins for animals, and to which corn raised in the farms were added to make feed concentrate. This locally made product is sold at ¥ 45 per kilogram, a little cheaper than the commercially available concentrates for cattle.

The rendering plant, which treats dead animals for disposal, produces waste products which can be used as animal protein supplement and as fertilizers. Figure 3 shows the system of circulation of the farm produce and waste products.

The present cooperative has been successful in helping farmers in producing, processing and marketing their own farm produce. Now a days, all the farm produce are processed into a new and more profitable form to give more profits to the farmers. It has also endeavoured to provide employment to the families of member farmers.

CASE II. REGIONAL INTEGRATED FARMING IN SHIHORO-CHO, A POTATO PRODUCING AREA

Shihoro-cho is one of the largest potato producing areas of Japan. The town has a population of 7,000 with 2,700 farm families. There are 580 farms with an average landholding of 22 hectares per family. It has a total of 12,600 hectares of tillable land planted to forage crop (37.6%), potato (22.2%), sugar beet (13.3%), wheat (9.4%), soybean (6.7%), Azuki beans (5.4%), and kidney beans (5.3%). The total share of potato after taking out the forage crops is about 35.6%.

The Agricultural Basic Law in 1971 which aimed at establishing regionalized farming throughout the country greatly affected the agricultural set-up in Japan, especially in Shihoro-cho in Hokkaido. The town leaders, following instructions to develop a regional and specialized farming, decided to improve and expand large areas of land for potato cultivation, to be sold as starch or table potatoes and ultimately to process them to maximize profits.

The agricultural cooperative's first project was the establishment of a large potato processing complex– the first of its kind ever built in Japan. The process included the use of radioactive Cobalt 60 to prevent the early germination of potato seedlings, thus prolonging storage. With this process, potatoes can be taken out of storage during off-season and sold at higher prices.

The successful development of Shihoro-cho as the country's 'Potato Kingdom' was mainly due to the following:

1. The agricultural cooperative selected only capable staff, mostly university graduates of agriculture, to manage the organization.

2. Members were encouraged to invest cash by offering interests higher than the commercial bank rates.

3. It leased all its machinery and equipment to farmers, hence more money was invested in the cooperative.

4. The local government and the cooperative helped each other in taking advantage of the subsidy from the national government.

5. The management staff promoted the latest available technology in the production and processing of potatoes.

How the agricultural cooperative succeeded in monocrop farming without losing soil fertility is described in the following section.

Feedlot Cattle Project

The development of the potato areas resulted in the excess of acreage far beyond the normal requirements for the long range scientific crop rotation. As a result, the need for fertilizing the soil with animal manure became essential. To solve the shortage of animal manure, the cooperative members agreed to raise feedlot cattle to serve as sources of organic matter. Initially, they preferred beef cattle because of the small amount of pasture they need and the less complex management they require compared to dairy cows.

Shihoro-cho has a small-scale slurry system with a piling floor for manure attached to the cattle barns. The farm users are organized in small groups of 10–20 member farms surrounding the feedlot cattle sheds. Each of these farms has a total acreage of 250–500 hectares. The facilities and equipment for storing, mixing, delivery and spreading of these fertilizers are located in the feedlot cattle barns and leased to farmers.

The cooperative purchases barn manure from member farms at the rate of ¥ 1,000 per ton. On the other hand, it charges ¥ 100 (US$0.50) for every ton of slurry materials applied in every farm and an additional cost of about ¥ 1,700 (US$8.5) for spreading and delivery.

At present, there are 12 leased feedlot cattle farms in the town. Their locations are shown in Fig. 4. These farms are major sources of organic fertilizers. The cattle sheds have two kinds of barns: one is a nursery for the newly born or newly purchased male calves (steer), and the other is the fattening shed for full grown steers. The nursery barns use saw dust and bark of trees for flooring, while the fattening sheds utilize slacked drain boards for easy and convenient collection of manure for slurry purposes. The nursery barns alone can produce a total of 1,500–1,700 tons of organic manure annually while the fattening sheds can accumulate 1,300–2,500 tons a year. Thus, one feedlot farm can supply 150–250 hectares of farmland using the standard of 20 tons of manure per hectare.

The agricultural cooperative later realized that it had been spending large amounts for purchase of steers for the feedlot farms. To avoid this expenditure, it established large-scale dairy farms that supplied its own animals for fattening. Dairy farming has been found also as a profitable enterprise, aside from being a source of male calves. Since 1971, the cooperative has established 10 dairy farms and has leased them to deserving and qualified member farmers. Fortunately, it was during these years that the government encouraged large-scale and modern farming through the Agricultural Structure Improvement Project and Dairy Modernization Laws. The cooperative took advantage of these opportunities in building its own modern and large-scale dairy farms, with at least 100 cows per farm.

The establishment of large-scale dairy farms has been beneficial to the agricultural cooperative. Some hilly areas, which otherwise would have been useless, were converted to pasture and planting sites for the production of hay needed by the feedlot farms. These areas are fertilized with the by-products of the potato starch factory, hence, the maintenance is very negligible.

One of the most important advantage for the dairy farms that were established in this town is that they have a good buyer of their steers– the agricultural cooperative. With its present number of 6,900 head, it can produce about 1,500–2,000 steers a year; roughly 1/3 of the total number of male calves needed by the feedlot farms are purchased annually by the cooperative. The manner by which the cooperative circulates these animals is shown in Fig. 5.

The use of the waste products from the potato starch factory as fertilizers for the pasture areas and for the lands devoted for hay production started in the Fall of 1975. Because of government restrictions and the public pressures on environmental pollution, the cooperative started using the factory effluents as fertilizers for grasses and hay needed by dairy cows. It built two reservoir tanks for storing the factory sewage. From the factory, the cooperative installed underground pipes which could reach some of the grassland farms of its members, where the wastes are sprayed by a rain-gun, free of charge.

The present cooperative helps the farmers by providing all the necessary equipment needed for the maximum production in the livestock and crop farms, and facilities (i.e., potato storage houses processing plants and starch factory) for storage, processing and marketing their produce in a more profitable form of commodity, (the agricultural facilities and other real properties of the cooperative are summarized in Table 2). The cooperative leases all the facilities and equipment to prevent individual over-investment by the farmers.

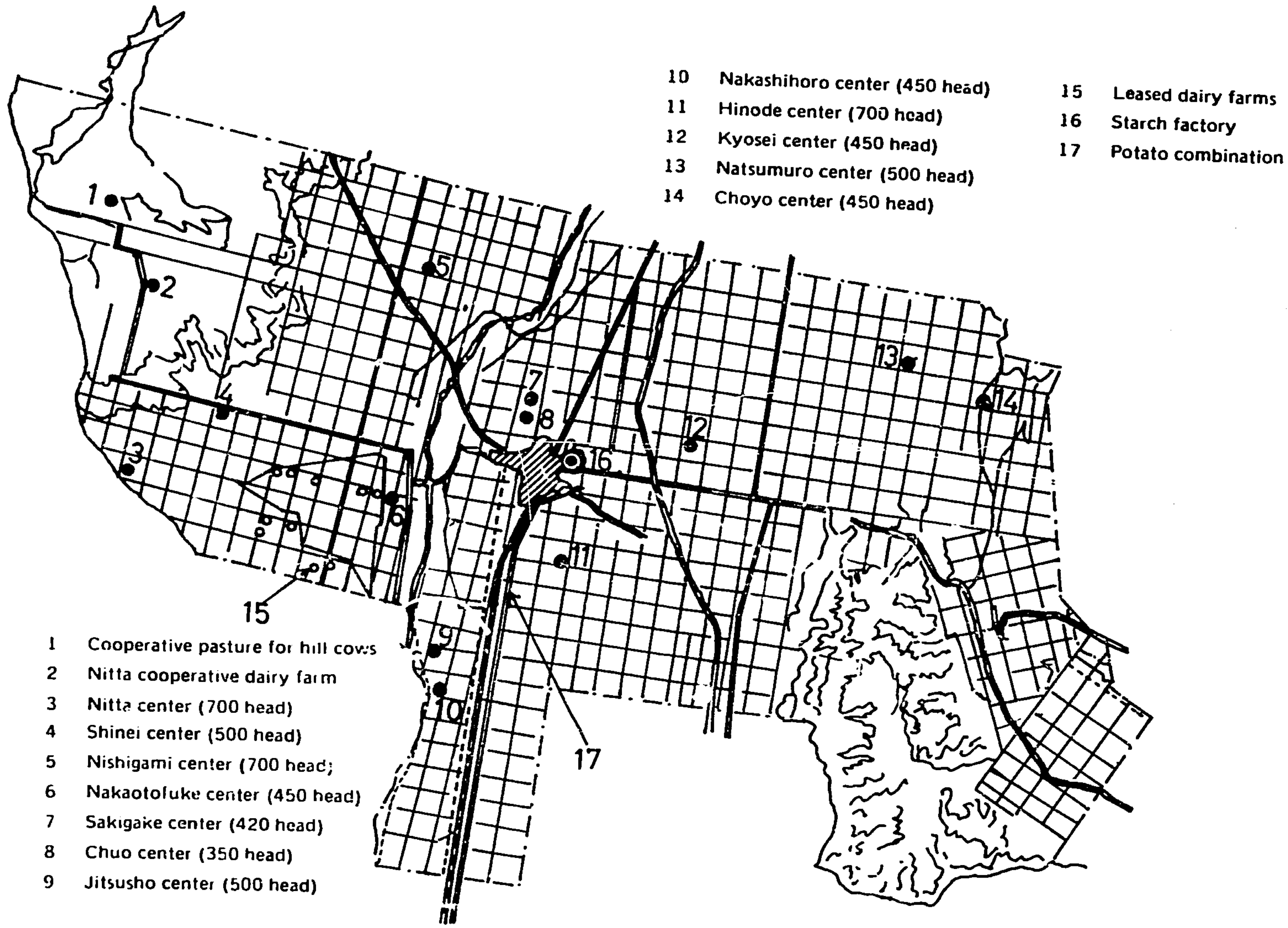


Fig. 4. The location of beef cattle fattening centers in Shihoro-cho

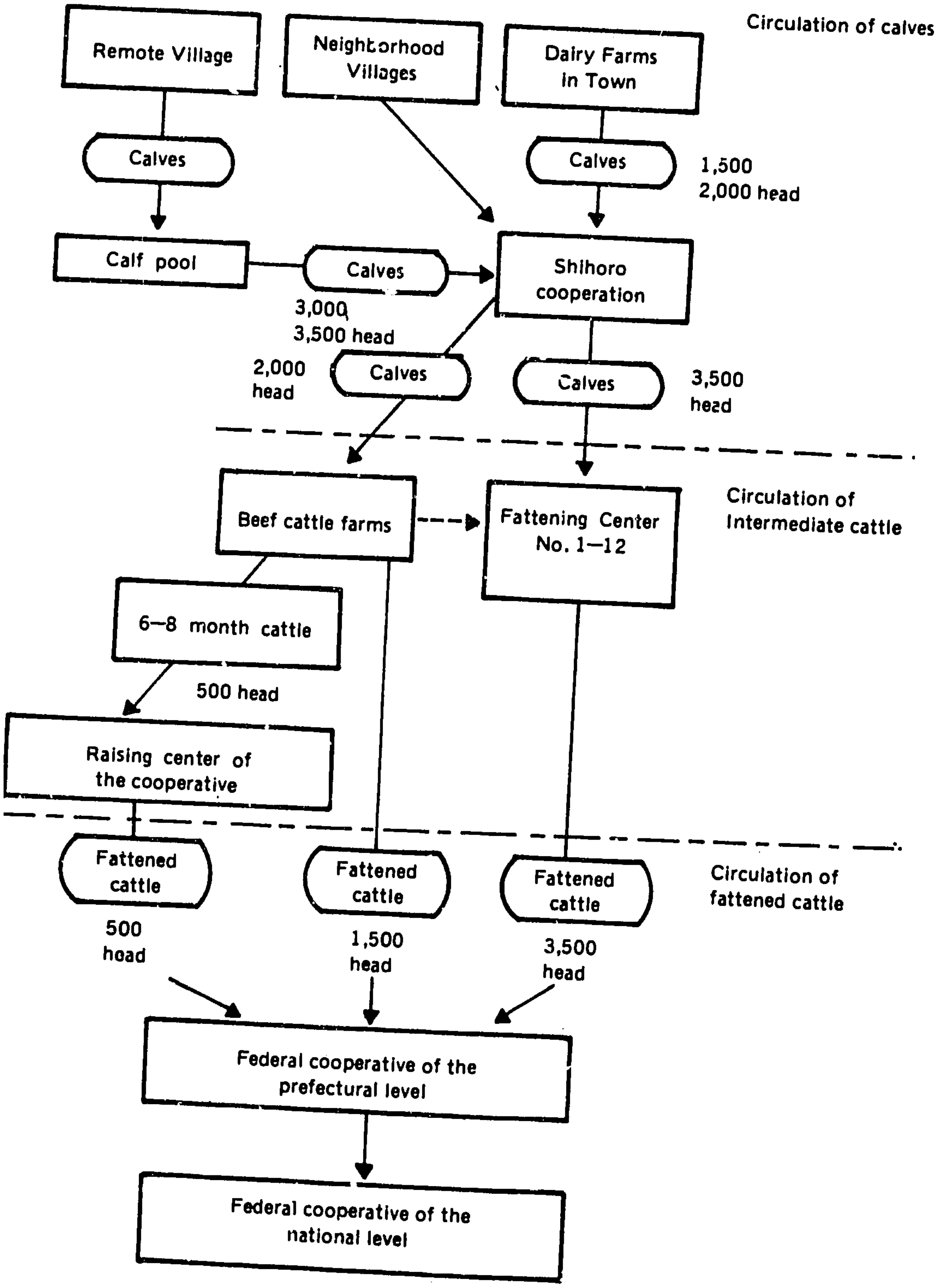


Figure 5. The circulations of beef cattle in Shihoro-Town

Table 2. Regional agricultural facilities owned by the Shihoro Agricultural Cooperative

Kinds of facilities	Construction year	Sizes and capacities
Drying facility for wheats	'68—'70	1,364 m^2 24 t/hr; 1,300 t/year
Potato starch factory	'55	9,346 m^2; 1,800 t/day
Cobalt 60 application facility	'73	1,912 m^2
Potato storage	'69—'78	17 storage; 45,236 m^2
Grading house of potatoes	'74	3,900 m^2 240 t/hr
Potato chips factory	'73	3,501 m^2 material potatoes 50 t/hr
French fry factory	'73	2,782 m^2 material potatoes 20 t/hr
Sugar beet storage	'69	Storage capacity 100 thousand tons
Cooperative use pasture	'71—'73	347 ha; pasturing 600 head; shed feeding in winter 200 head
Collecting facility of beef cattle	'70—'72	3,016 m^2 500 head
Beef cattle fattening centers	'70	12 places; one place 400—500 head
Cooperative dairy barn	'62	
Slurry stores and manure deposits	'76—'78	9 places; slurry store, manure deposit place

INTEGRATED RICE MILL AND FARM COMPLEX IN THAILAND: TEST MODEL FOR ENVIRONMENTAL ASSESSMENT*

by

Reynaldo M. Lesaca

BACKGROUND

This project, which is a private enterprise, should be of interest to decision makers throughout the region because of the economic and environmental benefits that can be secured by adopting its method of integrating rice milling with animal husbandry and farming (i.e., the raising of poultry, pigs and fish and farm crops).

Although the rice mill cum farm complex of M/S Kamol Kij Co., Ltd. is situated so near to metropolitan Bangkok, it is set in sylvan surroundings characteristic of rural Thailand. It is situated on the bank of the Chao Phaya river, which is used, with great convenience, for the transport of paddy into the mill and of rice from the mill. Most of the rice is exported and the river serves as a natural artery for this transport.

The mill has a capacity of 450 tons a day, the rice produced being largely parboiled. The process of parboiling requires hot water and steam for soaking and cooking and the first economy achieved in the mill is to burn the waste product, rice husks, in the boilers, thus avoiding the need for purchase of fuel for the purpose and the expense for proper disposal of the husks without causing environmental pollution. The burning of husks in the furnace leaves a residue that still contains a great amount of carbon, black ash, and this is fully utilized by using it for brick making.

Rice-bran, an important by-product of rice milling, is also fully utilized: the rice bran oil is extracted in a solvent plant; the defatted bran is fed to chicken, ducks and pigs; the droppings of chicken are added to the feed of the pigs; pig droppings and duck droppings are used to feed fish, and finally, the sludge from the fish ponds is used to fertilize crops. In this manner a non-waste system for utilization of residues is evolved which, apart from the main product rice, generates large amounts of protein for human consumption (*viz.* chicken and duck eggs and meat, pork and fish), while at the same time avoiding environmental pollution.

---

* This project is based on the rice mill cum farm complex operated by M/S Kamol Kij Co., Ltd. in Pathum Thani Province of the Kingdom of Thailand, about 30 kilometers to the north of Bangkok. The project could not have been written up without the kind permission of Mr. Kamjai Iamsuree, the proprietor of the concern, to observe the operations and Mr. Adirek Tunsarojvanich for explaining the processes and freely supplying data and information, at much cost of time and effort. The Regional Office of UNEP in Bangkok wishes to express its profound gratitude to them for this cooperation.

THE PROJECT

Nature: Agro Industrial
Title: Integrated rice mill, chicken, duck, pig, fish, and farm complex
Time Span: Continuing
Physical Boundary: Located in Pathumthani Province, Thailand.
Rice mill area: 120 rai; farm and livestock area: 30 rai
Cost[1]: Resources used: land, buildings, equipment, machinery, vehicles plus labor and management, etc.; Bht. 123,640,000[1]
Resources consumed: paddy, seed material, etc. Bht. 212,015,000
Working capital: Bht. 30,000,000
Products and Values[1]:

Product	Quantity p. a.	Value (Bht.)
Rice parboiled	29,450 tons	126,635,000
Rice white polished	11,880 tons	83,160,000
Rice brokens polished*	2,870 tons	7,175,000
Defatted bran polished*	2,490 tons	4,980,000
Rice bran oil	690 tons	7,245,000
Rice husks	31,000 tons	3,100,000
Bricks	3,600,000 nos	900,000
Chicken	2,000 nos	48,000
Ducks	4,000 nos	60,000
Pigs	6,200 nos	8,680,000
Hens' eggs	1,200,000 nos	1,200,000
Ducks' eggs	1,680,000 nos	1,680,000
Fish– Pla Duk	20,000 kg	320,000
Pla Sawai	65,000 kg	650,000
Pla Nil	8,000 kg	64,000
Farm produce*	Lumpsum	20,000
Total		245,917,000

Remarks: By integrating the milling of rice with the raising of poultry, pig and fish farming, waste is eliminated and a total utilization of resources is achieved. Part of the products marked with an* viz. rice brokens, defatted bran and farm produce are recycled and used as feed.

1 US$ = 20 Baht

---

1 Costs and values are not actuals, but have been calculated at assumed rates for purposes of illustration. This total is made up of (i) labor and management Bht. 13,500,000 and (ii) inventory Bht. 100,140,000.

Resources Used and Consumed

1. Directly

		(Baht.)
Rice Mill:	Land	7,500,000
	Buildings	30,000,000
	Machinery and equipment	40,000,000
	Vehicles	5,000,000
	Furniture and fittings	1,000,000
	Gunny bags	6,300,000
	Paddy bought	200,000,000
	Husks bought	60,000
	Electricity	3,000,000
	Solvent make up per year	400,000
	POL, repair maintenance	350,000
	Total	Bht. 293,610,000
Bricks kilns:	Land	750,000
	Machinery– extruder	1,000,000
	Clay	25,000
	Total	Bht. 1,775,000
Chicken, ducks, pigs:		
	Land	100,000
	Buildings	6,000,000
	Machinery– mixer, bio-gas	325,000
	Vehicles	1,200,000
	Piglets bought	3,000,000
	Chicken bought	212,000
	Ducks bought	210,000
	Medicine	500,000
	Fish and kathin leaf powder	200,000
	Broken rice	4,122,000
	Total	Bht. 15,747,000
Fish:	Land	750,000
	Fingerlings bought	48,000
	Total	Bht. 798,000
Farm:	Land	65,000
	Machinery– tractor	150,000
	Seed material	10,000
	Total	Bht. 225,000
Labor and management:		
	Labor (including social security)	13,200,000
	Management	300,000
	Total	Bht. 13,500,000
	Grand total	Bht. 325,655,000

2. Indirectly

The mills depend on the public road system and the river and barges for transportation of raw materials and finished products and at the state electricity system for its requirements for operating the mill and for pumping water from the subsoil and/or river.

Products and Residues

1) Products derived directly from the farm complex

a. *Rice* is the most important product of the milling of paddy and constitutes about 66 per cent of the paddy. In this project, about 70 per cent of the rice produced is parboiled and 30 per cent is white polished rice. The entire quantity of the rice produced is sold.

b. *Rice brokens.* About 5% and 10%, respectively, from parboiled and dry rice is produced as brokens. A portion of the broken rice is used as feed for chicken, ducks, and pigs, but the most of it is also sold.

c. *Rice bran* is another by-product from the milling of rice. This contains from 15% (white rice bran) to 24% (parboiled rice bran) vegetable oil.

d. *Rice bran oil,* which is extracted from the bran by the solvent extraction process, is another product. It is sold to be refined and used as cooking oil.

2) Products derived directly as residues

a. *Rice husks* form an important residue and constitute about 20% of the paddy. In this project they are all burned to produce steam required for a) the steam engine, b) the process of parboiling (heating the soaking water and for parboiling itself), c) drying parboiled paddy and, d) bran-oil extraction. Sometimes, when input is less than normal and the husk is not sufficient to produce steam for the engine to run the mills, the mill uses electric power purchased from the generating authority. A major part of the steam is used to dry parboiled rice, about 120 tons per day against the daily production of about 250 tons. Part of the drying is done under the sun, with paddy spread out on large drying platforms.

b. A residue of the burning of husks is *waste heat in the blue gases.* This was used on an experimental basis to dry paddy of about 20 tons. The experiment has been successful and it is proposed to extend it to recover all the waste heat from all the blue gases in 'energy conservers,' a system of slightly inclined horizontally rotating cylindrical steel kiln on gears.

c. The *'black ash,'* residue left after burning the rice husks, still contains about one-fourth energy in heating value in the form of carbon. This black ash is utilized to make bricks, by mixing with clay and firing in the kilns, along with some husks. A production of 3.6 million bricks per annum can be achieved.

d. The residue left after burning in the brick kilns is *'white ash'* which is a almost pure silica and sold for making insulators and abrasives.

e. *Defatted bran* is the residue from the solvent extraction plant and is used to feed chicken, ducks and pigs.

3) *Products derived indirectly utilizing residues*

By utilizing the residues created directly from the farm complex, important products are created indirectly:

a. *Chicken, ducks and pigs* consume de-fatted bran, as well as broken rice and mill sweepings (which contain grain) supplemented by other material. The following stock is raised:

6,000 hens– stock renewed every 1½ to 2 years (at 2 kg weight)
7,000 ducks– stock renewed every 1½ to 2 years (at 2 kg weight)
6,000 pigs– stock renewed every 6 months (at 100 kg weight)

The output is:

3,000 retired hens and 1,440 eggs per annum
3,500 retired ducks and 1,680,000 eggs per annum
12,000 pigs per annum

The chicken coops are built above the pig stalls and a significant portion of the chicken droppings are consumed by the pigs whose diet is also supplemented by chopped vegetable matter, broken rice, and deceased pigs and ducks which are cooked using biogas produced from chicken and pig manure. Duck droppings go directly into the fish ponds to be consumed by the fish. The pig droppings are used partly (100 kg per day) to produce biogas, but mostly to feed fish.

b. *Fish* The project has 120 rai (about 40 acres) of fish ponds in which freshwater fish, relished by the people of the area, are raised and sold in the market. The species of fish raised are Pla Nil (*Tilapia nilotica*), Pla duk (*Clarias batrachus*), and Pla Sawai (*Pangasius sutchi*). Fingerlings are bought from outside and the ponds are stocked with about 3,000 to the rai and sold when they are about 1–½ years old or have attained a weight of two kg each. The feed for the fish is mainly the pig droppings, plus whatever is washed down from the chicken coops and pigsties, left-overs from the chicken and duck feeds etc. Duck droppings go to the duck ponds directly to feed the fish in the pond. Some chicken excreta is also fed directly to the fish and it is found that droppings from 30 pigs and 60 chickens are required for one rai of fish. The gross production is about 24,000 kg of fish per annum.

Fish ponds generate sludge and the project also aims at utilizing this. It is an excellent source of plant nutrients. The purpose is to grow crops in the fish ponds after the fish are harvested. This has been started on a pilot scale and will be extended after experience is gained of the economics of using the same plot of land alternately for growing crops and for raising fish.

c. *Crops* Maize, sugarcane, pineapple and bananas are grown on about 30 rai of land. No paddy is grown because the land is not suitable for paddy. The vegetative parts of these crops, (e.g. bananas) make excellent pig and duck feed and is utilized for this purpose. The produce of corn, bananas, pineapple, sugarcane, etc. are also sold in the market.

d. *Residues* As described above, all the residues created are utilized to substitute for fuel for producing process steam and burning bricks, to feed poultry, ducks and fish and to fertilize farm land. Waste heat is also recovered.

There are no residues to affect neighborhood crops, fish, habitat etc. as no wastes– except blue gases, from which heat is recovered– are voided into the atmosphere, land or water. The voidance of the blue gases does not, in the ambience prevailing near the mill, cause any air pollution.

Resources — Exhausted/Depleted/Deteriorated

There is no exhaustion, depletion or deterioration of resources in this project. Resources brought in from outside are fully utilized.

The resources brought in from outside, mainly paddy, would to an extent, cause depletion of the soil nutrients in the fields in which it is grown, but as the growing of paddy is an operation outside the project no account of it is taken here.

The limited growing of crops such as maize, sugarcane, bananas and pineapple, attempted in this project does not cause any depletion of the soil nutrients in the small area shown because the nutrients are made up by the use of fish pond sludge.

Resources Enhanced

Significant enhancement of resources is achieved.

The utilization of *husks* to provide heat through the burning of 35,000 tons of husks totally eliminates a 'waste', which is thus converted into an enhanced asset and yielding an energy resource. It saves 22,400 tons of coal or 23,578 tons of firewood which would otherwise be required to raise steam. This amount of firewood would have needed 4,721 acres of land for its production. Calculations of the coal/firewood equivalent and of the area of land that would have been required to raise the firewood are shown in Annex III.

The further combination of *black ash* also results in savings of coal and fuel wood that would otherwise have been required for brick-making. The amount of saving has not been separately computed, being contained in the energy in the husk already computed.

The *white ash* left after black ash is burned further is almost pure silica and conserves an equivalent amount of the mineral that might otherwise have been used up.

The recovery of rice bran oil creates an equivalent amount of vegetable oil and an equivalent acreage of land required to cultivate the necessary oil seed is saved. It has been estimated that to produce the 690 tons of oil produced, 11,361 acres of land would have been required, an area that is thus made available for alternative uses.

The utilization of *de-fatted bran* and *chopped vegetable matter* to feed chicken, ducks and pigs, results in saving an equivalent amount of feed material that would have otherwise been necessary for producing their eggs and meat.

The utilization of *chicken droppings* for pig and fish feed and of duck and pig droppings for fish feed similarly becomes an enhanced new resource, saving equivalent amounts of the usual feed material.

The resulting increased availability of proteins for human consumption represents an enhancement of food resources.

Sludge from the fish ponds and biogas generator goes to fertilize farm lands where crops are raised and is therefore an enhanced resource replacing an equivalent amount of fertilizer that would otherwise have been necessary.

Required Additional Project Components for Resources Restoration, Maintenance, and Expansion (Potential Activities)

Little additional components can be envisaged in the particular project. However, a comment of wider import, may not be out of place.

Arising out of the success achieved in this project is the almost total elimination of wastes, and its conversion, instead, into useful resources. Worthwhile additional project components would be to extend the project country-wide. This project demonstrates how sizeable savings in fossil fuels and/or fuel wood are possible and how significant net additions to the quantum of proteins available for human consumption can be achieved by integrating the processing of paddy with the raising of chickens, etc. The calculations in the project are based on an annual milling of 75,000 tons of paddy. The production of paddy (rice) in Thailand is currently of the order of 13 to 14 million tons. The benefits that would ensue, if the system demonstrated in this project is extended to cover a fraction of this production, are obvious.

Not all paddy is processed in mills of the size in this project. There would be many smaller mills, hulling paddy. The collection of bran from such units to make up viable quantities for extraction of bran oil and the prevention of their deterioration may cause problems of logistics. But these are not insurmountable and these small units could achieve significant profits and enhancement of food resources if the system is adopted even partially.

As a part of the project, an experimental small demonstration farm, combined with the raising of chickens, pigs and fish has been laid out, and has been shown to yield a profit of nearly Bht. 30,000 per year as follows:

Receipts

30 pigs (weight 3,000 kg.) @ Bht. 15	45,000
12,200 eggs @ Bht. 1	12,200
40 chickens @ Bht. 20	800
1,400 kg Nilotica Tilapia @ Bht. 8	11,200
3,000 sugarcane @ Bht. 1	3,000
6,300 corn (3 x per year) @ Bht. 1	6,300
Total	78,500

Expenditures

30 piglets @ Bht. 300	9,000
Pigs' feed meal Bht. 4/pig/day	25,200
40 chickens @ Bht. 55	2,200
Chicken feed meal Bht. 0.45/day	6,570
5,000 fingerlings @ Bht. 0.20	1,000
Sugarcane (1 x per year) 3 rai @ 300	900
Corn (3 x per year) 3 rai @ Bht. 500/rai	4,500
Total	49,370

Net income .... Bht. 29,130

Perhaps a development on the national scale may be to encourage replication of such units on wide scale.

SUMMARY—DECISION MAKING

1. In this project, a rice mill is integrated with chicken/duck/pig and fish raising and with a small vegetable farm. Paddy is milled to produce rice and the waste products (rice husks) are burnt to provide the process heat required for parboiling paddy and this avoids the necessity for bringing in fuel from outside. By-products of the milling is rice bran from which rice bran oil is extracted. The de-fatted bran along with other residues such as broken rice, paddy floor sweepings etc. are fed to chickens, ducks and pigs, and these are totally converted into protein for human consumption in the form of meat and eggs. Chicken coops are built over the pigsties and chicken droppings go to feed the pigs. The pig droppings and duck droppings are fed to fish, thus producing more protein. Finally the fishpond sludge is used to fertilize growing vegetables representing more food. Vegetable residues are fed to pigs and ducks, thus achieving total resource utilization. The total value of the products is Bht 245,917,000.

2. The value of resources used and consumed is (i) inventory, Bht 100,140,000 (ii) labor and management, Bht 13,500,000 (iii) stores and supplies consumed per annum, Bht 212,015.000 making a total of Bht 325,655,000. The project has no indirect effects on the neighborhood crops, fish etc. Attempts are being made to recover wasted heat and particulates from the blue gases.

Valuable residues created in the project include rice, rice bran and rice bran oil, rice husks which in turn are used to provide process heat, for making bricks and for feeding chicken, ducks, pigs and fish which in turn provide fertility to a small area growing crops.

3. There is no exhaustion, depletion or deterioration of resources in this project.

4. Through total utilization of resources, significant enhancement of resources is achieved: fossil fuels and/or firewood are saved by the burning of husks; acreage which would otherwise have been required for growing oil seeds is freed. The quantum of protein available for human consumption is increased by raising poultry, pigs and fish.

5. Returns from the enhanced resource obtained through utilization of residues are summarized as follows:

22,400 tons of coal or 23,587 tons of fuel wood saved per annum
11,361 acres of land freed from growing oil seeds per annum
3,600,000 pcs of bricks produced per annum
2,000 chicken and 4,000 ducks per annum
6,200 pigs; 1,200,000 hens' eggs per annum
1,680,000 ducks' eggs and 93,000 kg. fish per annum plus about Bht. 20,000 worth of farm produce.

6. It is necessary to disseminate as widely as possible the methodology adopted in this project which achieves total elimination of waste and significant enhancement of resources. The methodology can be adopted similarly in large-scale operations as in this project as well as in small size family farms.

Appendix I

Cost/benefit assessment
(Environment additionalities)

In this project the main costs comprise all the expenditures required to establish and separate the rice mill. Also to be computed are the additional expenses to be incurred in dealing with the various wastes, viz. husks, defatted bran, etc. in an environmentally sound manner.

The benefits would be the value of products produced (viz. rice and rice bran oil) plus the value of all the products produced from utilizing the residues and from avoidance of any special anti-pollution measures for their handling and disposal.

The saving in fuel (fossil fuels or fuel wood), and in vegetable oil through recovery of rice bran oil are two important environmental additionalities achieved.

Similarly, the avoidance of pollution by utilizing wastes in a chain of consuming organisms represents an important environmental factor plus of course adding to the total availability of proteins.

Appendix II

Enlarged cost/benefit presentation[1]

Costs

		Bht
(i)	Cost of land, building, equipment, machinery, vehicles etc. for the mill and farm	100,140,000
(ii)	Labor and management per annum	13,500,000
(iii)	Stores and supplies consumed per annum	212,015,000
(iv)	Cost of disposal of residues viz. husks, black and white ash and bran in an environmentally sound manner (if they were not fully recycled)[2]	

Benefits

	Bht
GDP of products:	
Rice	216,970,000
Rice bran oil	7,245,000
Bricks	900,000
Chicken	48,000
Ducks	60,000
Pigs	8,680,000
Hens' eggs	1,200,000
Ducks' eggs	1,680,000
Fish	1,034,000
Farm produce	20,000
Deduct cost of:	
Effluent disposal	Nil
Add value of additionalities created[2]	
22,400 tons of coal or	
23,578 tons of firewood	
11,361 acres of land freed from vegetable oil seeds cultivation	

---

1 This is not a commercial balance sheet

2 Monetary value, not computed

Appendix III

Computations

Calorific value of rice husks	=	3,200 kcal/kg[1]		
Calorific value of coal (non-cooking)	=	5,000 kcal/kg[1]		
Tons of coal required to replace 35,000 tons of rice husk	=	$\frac{35,000 \times 3,200}{5,000}$	=	22,400 mt[2]
Calorific value of fire wood	=	4,750 kcal/kg[1]		
Tons of firewood required to replace 35,000 tons of husks	=	$\frac{35,000 \times 3,200}{4,750}$	=	23,578 mt[2]
Average growth of fuel wood per acre per year	=	5 mt[3]		
Acreage required to obtain 23,587 tons of fuel wood per year	=	23,587	=	4,721 acres
Average yield of oil seeds (sesame)	=	300 kg/ha[4]		
	=	121.45 kg/acre		
Acreage required to produce 780 mt of oil, assuming an extraction of 50%[5]	=	$\frac{780 \times 1,000}{121.25 \times 0.5}$		
	=	12,844 acres		

1 Values of calorific values adopted by various authorities are found to vary within very wide limits. Averages from several sources adopted.

2 Important: In this computation the fact that the burning efficiencies of coal and husks when burned to raise steam are very different has been ignored.

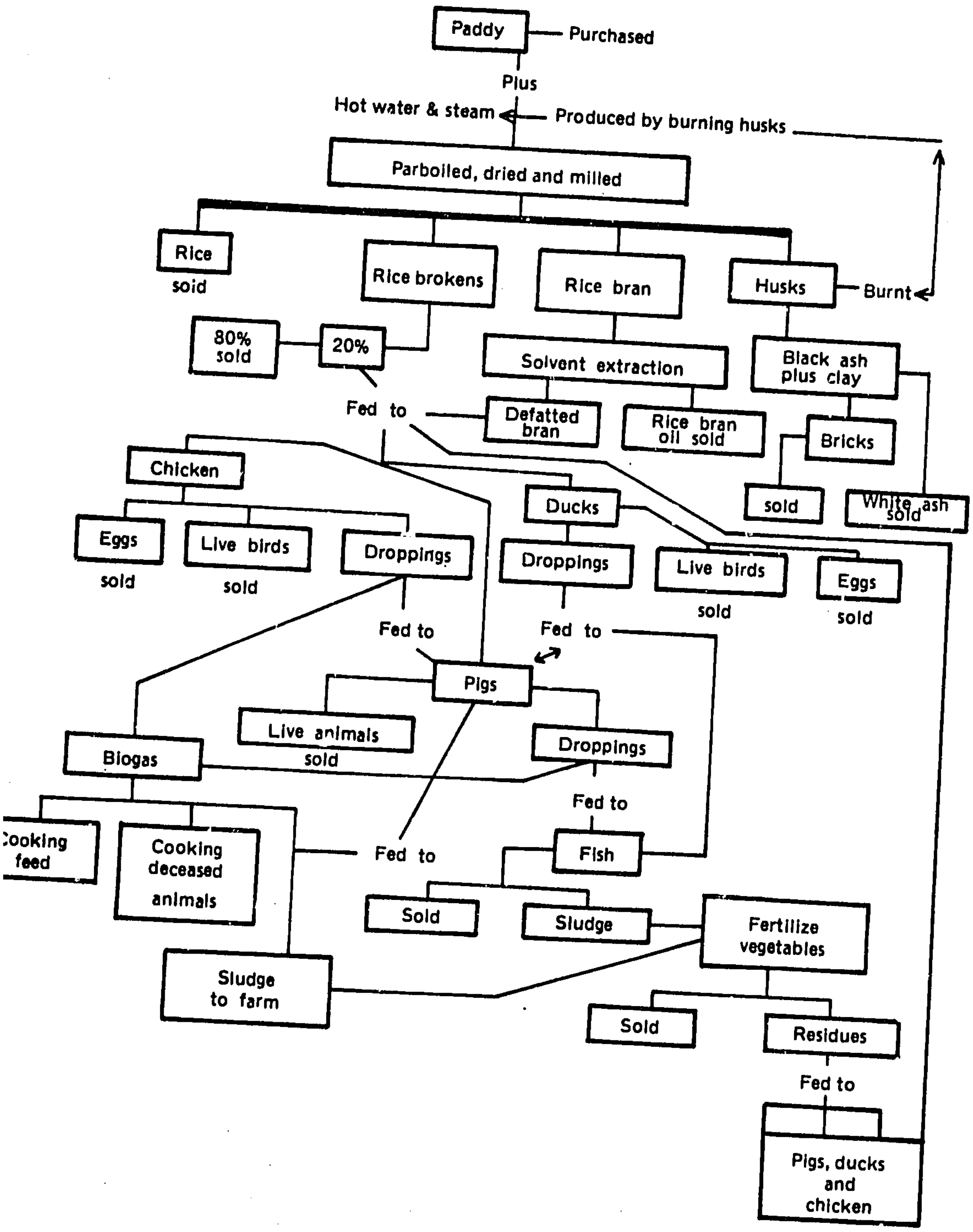
3 From Second India Studies: Energy. K. S. Parikh. Macmillian, New Delhi.

4 Averaged out from FAO production statistics.

5 Authorities give 41% to 65%. An average of 50% adopted.

Appendix IV

Flow diagram of rice mill/farm complex



245

AN ECONOMIC ANALYSIS OF THE INTEGRATED CROP-LIVESTOCK-FISH FARMING IN TAIWAN

by

Chaur Shyan Lee

INTRODUCTION

Presently, there is an increased awareness in Taiwan of the importance of integrated farming, especially in crop-livestock-fish farming. From the view of production efficiency or productivity, the use of farm resource is higher in integrated farming since the amounts of inputs are increased and the factor substitution is eased. On the other hand, from farm income aspect, the proportion of farmer's income from agricultural sector is higher in integrated farming. The results of a study on economic analysis of integrated farming and separate farming enterprise are discussed in the following sections.

This study was undertaken with the view of making a comparison of economic aspects of integrated farming with that of the separate enterprises. The specific objectives of the study were as follows:

1. To examine the impact of different types of farming on resource use
2. To analyze the benefit-cost ratio of different types of farming
3. To measure the production efficiency and farm income in different types of farming
4. To compare the efficiency of the integrated crop-livestock-fish farming with that of the other types of integrated farming and separate enterprises.

INDICATORS FOR COMPARATIVE STUDY OF ECONOMICS OF VARIOUS FARMING SYSTEMS

A number of indicators can be used for economic comparison of the different types of integrated farming and separate enterprises.

1. Benefit-cost Ratio

Benefit-cost analysis has become increasingly popular and useful since it can compute the direct and indirect costs and benefits of a specific enterprise. The easy way to measure the benefit-cost ratio of the specific enterprise is

$$K = \frac{FE}{PC} \qquad (1)$$

where FE stands for the farm earnings and PC represents the production cost; FE is equal to the difference between farm receipts and production cost.

2. Rate of Farm Income

The rate of farm income is also the indicator which can measure the production efficiency in the agricultural sector. Rate of farm income is computed using the formula:

$$R = \frac{FI}{FR} \qquad (2)$$

where FI is the farm income and FR is farm receipts. From the point of farm management, FR is equal to farm income and farm expenses. Based on equation (2) we can see that the larger the rate of farm income, *ceteris paribus*, the greater the production efficiency.

3. Factor Productivity

Factor productivity is a reciprocal concept of production efficiency and can be measured by output per unit of input. Setting the farm output as Q, the input of cultivated land as D, the input of labor as N and input of capital as C, land productivity and capital productivity could then be explained by Q/D, Q/N and Q/C, respectively. Actually, factor productivity can be derived by the relationship between factor productivity and factor-factor ratio. For example, labor productivity can be explained by (1) the relationship between labor productivity and land productivity and per labor land input by the following formula

$$Q/N = \frac{Q}{D} \cdot \frac{D}{N} \qquad (3)$$

and (2) the relationship between labor productivity and capital productivity and per labor capital input by the following expression

$$Q/N = \frac{Q}{C} \cdot \frac{C}{N} \qquad (4)$$

From equation (3) we can see that if the per capita land input (D/N) is held constant, then the increase in labor productivity (Q/N) in this case is entirely the contribution of the increase in land productivity (Q/D). As indicated from equation (4), if the per labor capital input (C/N) remains constant, then we can say that the increase in labor productivity (Q/N) is totally the contribution of the increase in capital productivity (Q/C).*

4. Elasticity of Substitution

With the two factors of production, labor (N) and capital (C), the elasticity of substitution is represented symbolically by

$$e = \frac{(C/N)\ d(N/C)}{(f_N/f_C)\ d(f_C/f_N)} \qquad (5)$$

---

* The land productivity and capital productivity can also be illustrated by the following expression.

Land productivity: $\frac{Q}{D} = \frac{Q}{N} \cdot \frac{N}{D}$; $\frac{Q}{D} = \frac{Q}{C} \cdot \frac{C}{D}$ Capital productivity: $\frac{D}{C} = \frac{Q}{D} \cdot \frac{D}{C}$; $\frac{Q}{C} = \frac{Q}{N} \cdot \frac{N}{C}$

where f_N and f_C are the marginal product of labor and marginal product of capital, respectively. The elasticity of substitution is the proportional change in the relative factor inputs to a proportional change in the marginal rate of substitution between labor and capital. The elasticity of substitution is one of the important indicators in measuring the production efficiency (or technological change). If e is larger, then a given change in the ratio of marginal products is associated with a larger change in the labor-capital ratio than that of a smaller e.

A CES (constant elasticity of substitution) production function was applied to measure the elasticity of substitution for this study (see Appendix 1).

THE DATA AND SCOPE OF THE STUDY

The data used in this study were taken from the farm survey undertaken by the Department of Agricultural Economics, Provincial Chia Yi Agricultural Junior College in 1979. This study included 175 farm households which were selected from the 320 farm households in the original survey. The sample included those engaged in different types of farming in the Southern area of Taiwan. The types of farming selected for the study were: crop, fish, livestock, crop-fish, crop-livestock, fish-livestock, crop-livestock-fish. A sample of 20–25 farm households were selected for each type of farming.

RESULTS OF THE STUDY

A. Characteristics of Integrated Farming in Taiwan

Economic aspects are emphasized in this study. The structure of farm income, sex, age and educational level of farm operator, and farm labor requirements were used to explain the general situation of different types of farming. Table 1 shows that the degree of diversification was higher in integrated farming and the diversity index in separate enterprises never exceeded an index of 2. The integrated crop-livestock-fish farming had the highest diversity index of 2.59, followed by the integrated crop-fish, fish-livestock and crop-livestock farming, with an index of 2.19, 2.06 and 2.04, respectively.

Table 1. The structure of farm income and the degree of diversification of different types of farming

Pattern	The structure of farm income					Diversity index (%)
	Crop (%)	Livestock (%)	Fish (%)	Others (%)	Total (%)	
Crop	95.29	—	—	4.71	100.00	1.10
Fish	2.91	13.71	83.37	0.01	100.00	1.40
Livestock	6.71	87.67	—	6.16	100.00	1.29
Crop-fish	46.73	5.74	46.32	1.21	100.00	2.19
Crop-livestock	48.79	50.27	—	0.94	100.00	2.04
Fish-livestock	2.00	55.72	41.72	0.56	100.00	2.06
Crop-livestock-fish	23.19	50.10	24.58	2.13	100.00	2.59

$$\text{Diversity index} = \frac{1}{\left(\dfrac{\text{Value of each product}}{\text{Value of total product}}\right)^2} = \frac{1}{\sum\limits_{i=1} \left(\dfrac{Y_i}{Y}\right)^2}$$

The labor requirements per hectare in integrated farming are higher than that in the separate enterprises; the simpler the type of separate farm enterprise (except livestock), the less need for labor per hectare. With respect to the family and hired farm labor distribution, the family labor played a significant role in providing a large part of labor in various types of farming. Of the seven types of farming, the relative importance of family labor per hectare is lower on separate farming (except the livestock) than on integrated farms (Table 2).

Table 2. Farm labor requirement and its structure in different types of farming

Pattern	Grand total		Family and hired labor				Family labor			
	Man-day	%	Family man-day	%	Hired man-day	%	Male man-day	%	Female man-day	%
Crop	269.83	100.00	217.73	80.69	52.10	19.31	159.86	73.42	57.87	26.58
Fish	230.61	100.00	205.70	89.20	24.91	10.80	135.91	66.07	76.17	37.03
Livestock	969.46	100.00	828.01	85.41	141.45	14.59	478.92	57.84	349.09	42.16
Crop-fish	365.71	100.00	313.20	85.64	52.51	14.36	188.64	60.23	124.56	39.77
Crop-livestock	463.96	100.00	418.08	90.11	45.88	9.89	267.61	64.01	150.47	35.99
Fish-livestock	570.71	100.00	512.45	89.79	58.26	10.21	341.60	66.66	170.85	33.34
Crop-livestock-fish	629.34	100.00	554.78	88.15	74.56	11.85	322.66	58.16	232.12	41.84

B. Resource Use in Integrated Farming

The scarcity of land resources in Taiwan requires year round utilization of land for crops and livestock. Past experience shows that the smaller farmers more effectively increased their multiple-croppihg index to maximize the use of their farm land and sustain their levels of living.

The average man-equivalent per hectare in separate enterprises (except livestock) is lower than in the integrated farms (Table 3). We can see that the integrated crop-livestock-fish had the highest average man-equivalent per hectare of 1.85 among the integrated farms; fish-livestock, crop-livestock and crop-fish had a man-equivalent of 1.71, 1.39 and 1.04, respectively.

The impact of intensive farming on the requirements of labor per hectare can be seen in a cross section analysis of different types of farming from the farm survey data as shown in Table 4. The relationship between the different types of farming and the requirements of farm labor per hectare is very significant.

It is also significant to note that increase in farm capital input per hectare depends on whether the enterprise is separated or integrated. The amount of farm capital input per hectare is higher on integrated farming than on separated ones as also shown in Table 3.

C. Economic Analysis of the Integrated Farming Enterprises

Integrated farming in Taiwan has significantly affected 1) benefit-cost ratio and rate of farm income and 2) factor productivity and elasticity of substitution.

Table 3. Resource use in different types of farming

Patterns	Land area (ha)	Average man-equivalent per hectare	Labor requirements per hectare (man-day)	Capital inputs per hectare ($NT)
Crop	1.09	0.73	269.83	85,385
Fish	2.24	0.69	230.61	89,207
Livestock	1.07	2.76	969.46	340,977
Crop-fish	1.78	1.04	365.71	107,968
Crop-livestock	0.82	1.39	463.96	110,739
Fish-livestock	1.56	1.71	570.71	131,203
Crop-livestock-fish	1.88	1.85	629.34	140,054

1. **Benefit-cost ratio and rate of farm income**

Integrated farming increased not only the overall agricultural output but also the family farm income. Table 4 gives the benefit-cost ratio and the rate of farm income of different types of farming in Taiwan. It is very difficult, however, to give a general estimation of the total family farm income including the off-farm income, since the extent of off-farm income can be increased depending on how many members of the farm family work outside the farm.

From the viewpoint of farm income, the benefit-cost ratio is highly related to the different types of farming. The simpler separate farming enterprises showed lower farm income and benefit-cost ratio than that of integrated farming (Table 4). The rate of farm income increased, *ceteris paribus*, with increase in the diversity of farm enterprise. The lowest rate of farm income (41.31) was obtained on crop farm and the highest (62.99) on fish-livestock farm.

Table 4. Benefit-cost ratio and rate of farm income of different types of farming

Patterns	(1) Farm receipts	(2) Production cost	(3) Farm income = (1) − (2)	(4) Ratio farm income production cost = (3)/(2)	(5) Rate of farm income = (3)/(2) x 100
Crop	145,472	85,385	60,087	0.7037	41.31
Fish	170,055	89,207	80,848	0.9063	47.54
Livestock	732,047	340,977	391,070	1.1469	53.42
Crop-fish	222,485	107,968	114,517	1.0607	51.47
Crop-livestock	262,417	110,739	151,678	1.3697	57.80
Fish-livestock	354,546	131,203	223,343	1.7023	62.99
Crop-livestock-fish	350,299	140,054	210,245	1.5012	60.02

2. Factor productivity and elasticity of substitution

From the farm survey data, the integrated farming showed a certain significant relationship with the factor productivity which varied among the different types of farming. Average data from farm survey in southern area in Taiwan in 1978 indicated that the different types of farming are closely related to land productivity, labor productivity and capital productivity (Table 5 and Fig. 1). Factor productivity per hectare increased considerably with the adoption of intensive agricultural operations, such as integrated farming.

The factor productivity of integrated fish-livestock farm has advanced remarkably, owing to two major factors: 1) the increase of production per hectare, and 2) the profitable prices of fish and livestock, especially during the year under review, compared with the price of crop.

Factor productivities are usually conceived as the important indicators of the level of economic efficiency of production in small farming in Taiwan. One important implication from the foregoing analysis should now be clear: integrated farming has made significant contribution to the growth of land, labor and capital productivities. Hence, policy makers should put attention on how this type of farming enterprise could be more effectively promoted to the farm sector.

With respect to the elasticity of substitution, we used the static CES production function in using the cross-sectional data in order to examine the elasticity of substitution of production on different types of farming. The equation was estimated by ordinary least squares regression based on cross-sectional data from farm survey. The results are shown in Tables 6 and 7.

Based on the analysis of factor productivities as mentioned above, it is very clear that technological effects on the productivities of resources in different types of integrated farming were significant. With the relative increase in capital inputs (or farm expenses) and relative decrease in labor inputs, capital inputs were significant substitutes for labor inputs and the labor saving technology has been considerably utilized in the integrated farms.

As indicated in Table 8, the high elasticities of substitution between capital and labor in integrated farming were primarily in the fish-livestock and crop-livestock-fish farming. The values of elasticity of substitution were less than 0.5 ($a < 0.5$) in the separated farmings (except livestock) and were greater than 0.5 ($a > 0.5$) in the integrated farming; the value of elasticity of substitution was particularly greater than 1 ($a > 1$) in the integrated crop-livestock-fish farming. This is because the amount of capital input is growing more rapidly than that of labor input in this type of farming.

Table 5. Productivity and factor-factor ratio in different types of farming

Patterns	Per labor capital input C/N (NT$/manday)	Per capital labor input N/C (manday/NT$)	Per capital hectare input D/C (ha/NT$)	Per hectare capital input C/D (NT$/ha)	Per labor hectare input D/N (ha/manday)	Per hectare labor input N/D (manday/ha)	Land productivity Q/D (NT$/ha)	Labor productivity Q/N (NT$/manday)	Capital productivity Q/C (NT$/NT$)
Crop	316.44	0.0032	0.00026	78,335	0.0037	269.83	145,472	539.13	1.70
Fish	386.83	0.0026	0.00050	39,824	0.0043	230.61	170,055	737.41	1.91
Livestock	351.72	0.0028	0.00006	318,670	0.0010	969.46	732,047	755.11	2.15
Crop-fish	295.23	0.0034	0.00028	60,656	0.0027	365.71	222,485	608.37	2.06
Crop-livestock	238.68	0.0042	0.00015	135,048	0.0022	463.96	262,417	565.60	2.37
Fish-livestock	229.89	0.0044	0.00024	84,105	0.0018	570.71	354,546	621.24	2.70
Crop-fish-livestock	222.54	0.0045	0.00021	74,497	0.0016	629.34	350,299	556.61	2.50

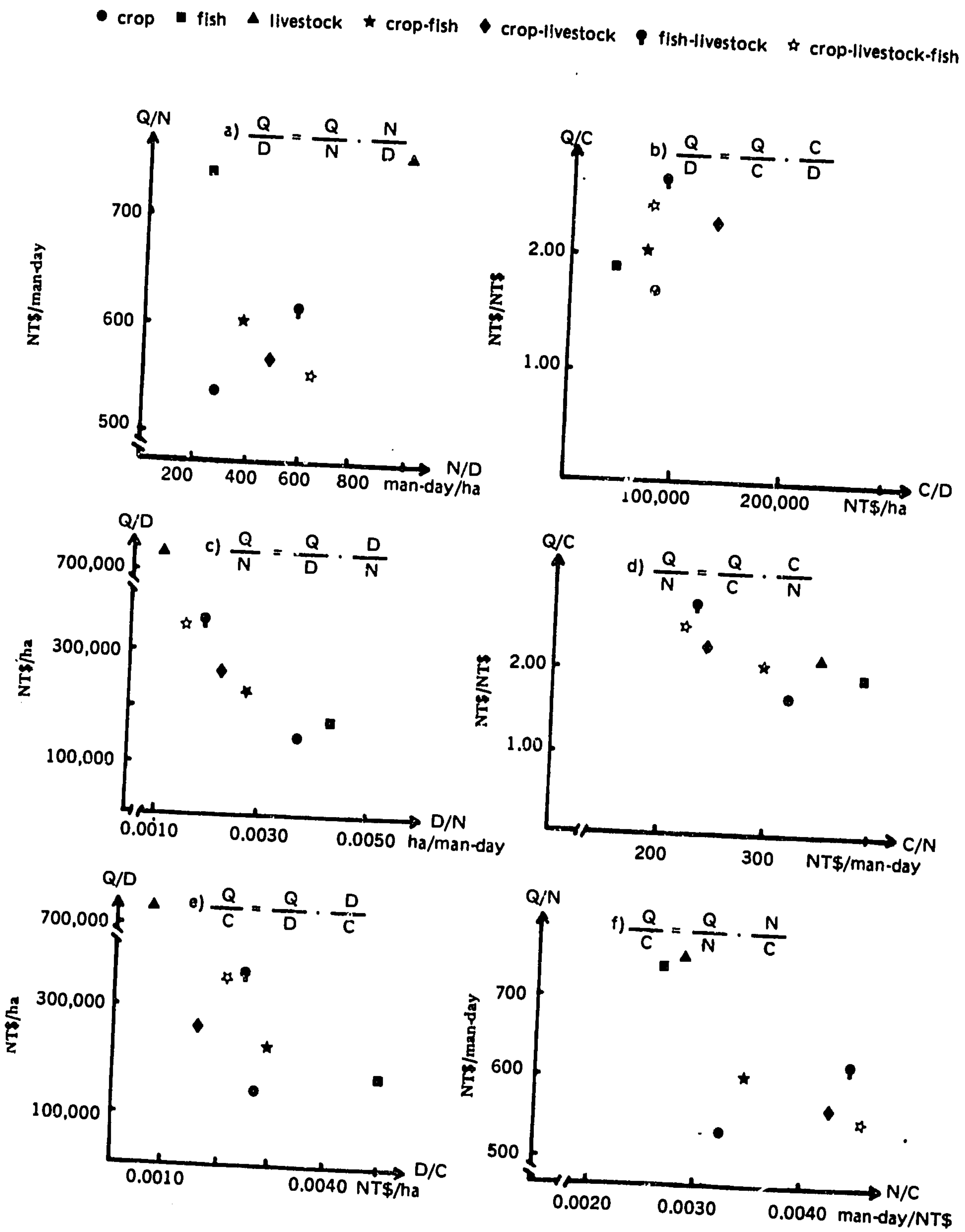


Figure 1. Land productivity, labor productivity and capital productivity in different types of farming

Table 6. Results of estimation of the CES production function

Patterns	β_1	β_2	β_3	β_4	F	R	n
Crop	0.1952	0.3847	0.4888	−0.3668	11.1368	0.6762	25
		(0.6431)	(0.9558)	(−0.9888)			
Fish	−0.1602	1.0438	0.0629	−0.1112	46.4974	0.8927	23
		(11.7141)	(0.4238)	(−0.5724)			
Livestock	1.1637	0.8904	−0.4472	0.3423	28.2473	0.8412	21
		(6.6221)	(−1.8612)	(2.9875)			
Crop-fish	1.1744	0.9590	−2.2724	0.1813	30.4164	0.8753	20
		(0.4722)	(−0.8556)	(1.4937)			
Crop-livestock	0.5833	0.5580	0.2666	−0.0698	18.3976	0.7753	20
		(0.8158)	(0.4049)	(−0.1542)			
Fish-livestock	0.3100	0.7096	0.2615	0.0351	109.3408	0.9535	20
		(9.4976)	(1.4917)	(−0.4018)			
Crop-livestock-fish	−0.1709	0.6844	0.4292	0.0027	31.9684	0.8888	21
		(2.8038)	(0.9213)	(0.0077)			

Notes: 1) Estimated based on CES production function (see Appendix 1)
2) t-value in brackets.
3) n is the number of farm household.

Table 7. Estimated parameters of the CES production function

Patterns	$\hat{\gamma}$	$\hat{K}$	$\hat{V}$	$\hat{\rho}$	$\hat{\sigma}$	R^2	S
Crop	1.5676	0.4404	0.8735	3.4032	0.2271	0.6762	0.1128
Fish	0.6951	0.9432	1.1067	3.7471	0.2107	0.8972	0.1414
Livestock	58.0337	1.9978	0.4482	0.7662	0.5662	0.8412	0.1469
Crop-fish	14.9417	1.3967	0.6866	0.9532	0.5120	0.8753	0.1170
Crop-livestock	3.8312	0.6767	0.8246	0.7743	0.5636	0.7753	0.1534
Fish-livestock	2.0419	0.7307	0.9712	0.3668	0.7316	0.9535	0.0823
Crop-livestock-fish	0.6748	0.6146	1.1136	−0.0205	1.0209	0.8838	0.0998

Note: Computed based on Table 6.

CONCLUSION

Integrated farming contributed to the maximal use of farm resources such as farm land, labor and capital, and resulted to larger farm income, higher factor productivities and a more equitable distribution of farm labor.

Benefit-cost ratio, rate of farm income, factor productivity and elasticity of substitution, which can measure the production efficiency were significantly different among the different types of integrated farming. From the view point of production efficiency and farm income, fish-livestock farming in Taiwan is more profitable than that of other integrated enterprises. However, in the factor substitution measured by the elasticity of substitution, the integrated crop-livestock-fish enterprise appears to be significant than the other types of integrated farming.

REFERENCES

Bardhan, P. K. 1973. Size, Productivity and Returns to Scale: An Analysis of Farm Level in Indian Agriculture. Jour. of Political Economy, Vol. 81. pp. 1370–86.

Brown, M. 1968. On the Theory and Measurement of Technological Change. Cambridge Univ. Press. p. 18

Britton, D. K. and N. B. Hill. 1978. Differences in Efficiency by Farm Size and Tenure. Paper pres. to AES Conf., Dec. 1978.

——— and N. B. Hill. 1975. Size and Efficiency in Farming. Farnborough Saxon House.

——— 1970. Analysis of Net Farm Income: An Examination of Farm Management Survey Data. Jour. of Agric. Econ. Vol. 21. pp. 351–371.

Dellaquaglia, A. P. 1978. Size and Efficiency in Scottish Agriculture. Scot. Agri. Econ. Vol. 28. pp. 149–158.

John Adams and Balu Bumb. 1979. Determinants of Agricultural Productivity in Rajasthan, India: The Impact of Inputs, Technology and Context on Land Productivity, Economic Development and Cultural Change. The Univ. of Chicago Press. pp. 705–722.

Lee Chaur Shyan. 1978. Technological Change and Labor Utilization: Case Study of Rice Farming in Taiwan, Jour. Agric. Econ., Taiwan, Vol. 24. pp. 127–186.

——— *et al.* 1975. Impact of Multiple-crop Diversification on Farm Income in Taiwan. The Phil. Econ. Jour. No. 27. pp. 77–87.

Lund, P. J. and P. G. Hill. 1979. Farm Size, Efficiency and Economics of Size. Jour. of Agric. Econ. pp. 145–158.

Lingard, J. 1978. Size and Efficiency in Farming, Can Production Function Help? Paper pres. to AES Conf., Dec. 1978.

Spencer Dunstan S. C. and Byerlee Derek. 1976. Technical Change, Labor Use, and Small Development: Evidence from Sierra Leone. Amer. Jour. of Agric. Econ., pp. 72–84.

Thirsk Wayne. 1974. Factor Substitution in Columbian Agriculture. Amer. Jour. of Agric. Econ., pp. 72–84.

Appendix 1. The derivation of the CES production function

The static CES production function is

$$Q = \gamma\, [\, kC^{-\rho} + (1-k)^{-\rho} N]^{-v/\rho} \tag{1}$$

Where Q, C and N represent output, capital and labor, respectively; the four parameters are γ, k, v and ρ, where γ stand for a scale parameter, k is the distribution parameter; v represents the degree of homogeneity of the function or the degree of return to scale, and ρ is the substitution parameter equal to $(1-\sigma)/\sigma$, where σ is the elasticity of substituion. Then we can compute the σ, where $\sigma = 1/1+\rho$.

The logarithmic transformation of the CES production function is

$$\log Q = \log\gamma - v/\rho \log\, [\, kC^{-\rho} + (1-k)\, N^{-\rho}] \tag{2}$$

The major problem with this production function is how to obtain an estimate of the parameters, γ, k, v and ρ given data on output, capital and labor input. A simple least-square method cannot be estimated directly to equation (2), since the term $[k\, C^{-\rho} + (1-k)\, N^{-\rho}]$ contains undetermined parameters.

A more simple estimation of the parameters of the CES production function is possible if we replace equation (2) by its approximation that is linear with respect to ρ. By using Taylor's Series Formula, (1) expanding log Q around $\rho = 0$, and dropping the terms involving power of ρ higher than one, (2) then we can obtain.

$$\log Q = \log\gamma + vk \log C + v(1-k) \log N - \tfrac{1}{2}\rho\, vk \\ (1-k)\, [\, \log C - \log N]^2 \tag{3}$$

The unrestricted version (3) can be estimated empirically as follows:

$$\log Q = \beta_1 + \beta_2 \log C + \beta_3 \log N + \beta_4 (\log C - \log N)^2 \tag{4}$$

The parameters of equation (3) are related to the coefficients of equation (4) as follows:

γ = antilog $\qquad v = \beta_2 + \beta_3$

$k = \beta_2/\beta_2 + \beta_3 \qquad \rho = {-2}\beta_4\, (\beta_2 + \beta_3)/\beta_2 \cdot \beta_3$

Thus we can use ordinary least square to estimate the coefficients of equation (3) from cross sectional data.

---

(1) The Taylor's series expansion of f(x) about the point x = a can be written as

$$f(x) = f(a) + (x-a)\, f'(a) + \frac{(x-a)^2}{2} f''(a) + \frac{(x-a)^3}{3} f'''(a) + \ldots\ldots\ldots\ldots + \frac{(x-a)^p}{p} f^{(p)}(a) + R_{p+1}$$

Where R_{p+1} = remainder.

(2) See J. Kmenta., On Estimation of the CES Production Function International Economic Review, June 1967, pp. 180–192.

DISCUSSION

Comment: With Japanese experience, capital productivity usually goes down if farmers increase or include more enterprises in certain farm sizes; land productivity maybe increased. You mentioned about increase of capital productivity in diversified farming, but maybe this is not in terms of introducing or putting investments on some machinery but only on small hand-tools.

A. I agree that capital productivity and land productivity change according to type of farming. A survey done in 1958 showed that the price of crops was relatively low compared to fish and livestock. From the point of view of production efficiency crop-livestock is more efficient than fish-livestock.

Q. Table 5 shows that in terms of cost-benefit ratio, fish-livestock is most efficient. However, on Table 6, land-labor productivity ratios indicate that livestock farms are more efficient among the enterprises. Can you explain these conflicting results on the factor productivity ratios?

A. Comparison was made on the same basis per hectare; as such, productivity from livestock enterprise was higher.

Comment: Some economists don't believe in factor efficiency ratios as an indicator of productivity; in other words, economic efficiencies cannot be measured by using productivity ratios.

Comment: The measurement of livestock productivity in this case is not farm size (area) oriented.

Q. Tables 5 and 6 show that in terms of farm income, livestock has the highest; in terms of capital productivity, fish and livestock is the highest. What would you recommend as the best pattern of enterprise to be supported?

A. In integrated farms, fish-livestock would be best where they are appropriate (location-specific); in separate enterprises, livestock is the best.

UTILIZATION OF HOG WASTES IN TAIWAN THROUGH ANAEROBIC FERMENTATION

by

C. M. Hong*, M. T. Koh*, T. Y. Chow*, P. H. Tsai** and King-Thom Chung***

INTRODUCTION

In Taiwan few studies have been done on hog management, especially the treatment of hog wastes. The production of methane through anaerobic fermentation of hog wastes was practiced during World War II[3], but its importance was not recognized until 1970.

Biohazards of water pollution caused by hog wastes have been ignored by the public. In recent decades, the size of hog raising farms in Taiwan has rapidly increased[15] and pollution problems caused by hog wastes are getting serious. In 1973, the government of the Republic of China placed restrictions on water pollution, limiting the biological oxygen demand (BOD) and suspended solid (SS) of waste water to 200 ppm.

In 1974, the Union Industrial Research Institute, Hsinchu, Taiwan (UIRI), invented the red mud plastic (RMP) for building the anaerobic digester for treatment of hog wastes[6]. Many improvements have been made since then, and the RMP has proved to be very practical.

If the RMP bag is used as the digester of hog wastes, and if the duration of hydraulic retention lasts 15 days, each hog requires a space of 0.3 m^3 for the digester. The BOD of the effluent can be kept below 160 ppm, thus preventing water pollution. If the methane produced is completely used for fuel, the total investment can be recovered within 5 to 9 months. This is the most economical method for the treatment of hog wastes. The general aerobic treatment would cost US$30–50 per hog, not counting the cost of electricity. In the United States, the lagoon system is the most commonly used method but it requires a space of 12 m^3 for each hog[4]. Such requirement of big space is not feasible in a land-limited country as Taiwan where the method of anaerobic treatment is economically worthwhile. The RMP can also be used for cover on the anaerobic lagoon, providing for methane recovery.

The methane generated through the anaerobic digestion of hog wastes can be used directly for fuel. For a family of five, 7 head of hogs will provide sufficient methane for house fuel. Methane can replace propane gas completely. Methane can also be used to generate electricity by modification of the carburetor.

The effluent from the anaerobic digester can be used for the cultivation of green or blue-green algae which can be harvested for animal feed. *Spirulina platensis* is cultivated successfully in Taiwan for this purpose.

* Taiwan Livestock Research Institute, Hsin-Hua, Tainan, Taiwan 712, Republic of China.
** Tainan Fish Culture Station of Taiwan Fishery Research Institute, Chi-Ku, Tainan, Taiwan 724, Republic of China.
*** Department of Biology, Tunghai University, Taichung, Taiwan 400, Republic of China.

It has been estimated that the methane produced from wastes of 5 million hogs will total 315 million m^3, equivalent to 2.9×10^{12} Kcal (Ray, M. H., Personal communication). As such, the methane produced from hog wastes will be 15–20% of the annual natural gas produced in Taiwan. The subtropical climate of Taiwan is extremely suitable for the natural anaerobic fermentation of hog wastes. The economical quality of RMP material helps to decrease the cost of constructing a good digester locally. Other types of wastes such as city sewage and wastes from other livestock can also be used for the production of methane through anaerobic fermentation. Therefore, the potential of production of methane through the anaerobic fermentation of wastes is enormous.

ADVANTAGES OF ANAEROBIC TREATMENT OF HOG WASTES

In general, treatment of hog wastes can be aerobic or anaerobic. The advantages of anaerobic treatment are. a) a high degree of waste stabilization; b) low production of waste biological sludge; c) low nutrient requirements; d) production of methane as a useful end product; e) no oxygen required. The disadvantages of this treatment, on the other hand, are: a) limitation of temperature; b) the slow growth rate of methanogens[12].

In aerobic treatment, the aerobes consume oxygen and convert the organic materials from the wastes into carbon dioxide and water in order to obtain energy for the cells. The majority of organic materials are transferred into new microbial cells. The effluent requires further treatment to decrease the biological oxygen demand (BOD) or suspended solid (SS). In anaerobic treatment, the organic materials are converted primarily into carbon dioxide and methane, only a small amount of the organic materials are transferred into new cells. The large quantity of methane can be collected as an energy source since it is not water soluble.

It was estimated[3] that 0.3 m^3 of biogas was produced per day per hog (average body weight of 90 kg) when hog wastes were anaerobically treated. Methane constitutes 65% of the total biogas. The energy produced by the methane is, therefore, 1820 Kcal (7220 BTU). If the duration of hydraulic retention lasts 12 to 16 days, 80% of the BOD can be eliminated. Wang *et al*[16] also reported that in the winter, with temperature between 13 and 23°C, by employing the multiple chamber-digesters for the treatment of hog wastes, 0.1 m^3 biogas (65% CH_4) was produced per day per hog (body weight of 50–60 kg). The BOD decreased from 6690 ppm to 160 ppm when the duration of hydraulic retention lasted 19 days (Wang, H. H., T. H. Liu, C. M. Hong and M. T. Koh, 1976. Special report on the 2nd national conference of waste water treatment).

Due to warm weather in subtropical area, the anaerobic treatment of hog waste is advantageous. If the digester can be installed underground to decrease the occupant space and to minimize the influence of cold weather in winter, better efficiency can thus be obtained.

According to the report of Yen and Wang[17], the effluent after the anaerobic fermentation of hog waste contains nitrogen 1.00g/l (0.11%), P_2O_5 0.148g/l (0.01%) and K_2O 0.911g/l (0.09%). Since the nitrogen content is high, it is a good fertilizer. This finding has been confirmed through the field experiment[2].

Lee and Huang reported[11,7] that parasites and pathogens in the hog wastes were killed or inhibited after anaerobic fermentation. Therefore, the anaerobic fermentation of hog waste can provide good fertilizer for farming and the effluents can still be used for the cultivation of algae.

CHARACTERISTICS OF WASTE WATER AND METHOD OF CLEANING

Composition of waste water from the piggery

The major components of waste water coming from the piggery are feces, urine, wash water, feed residues and grasses. The quantity and quality of waste water are affected greatly by the amount of fecal and urine excretion and the amount of water used for cleaning the piggery. The amount of water used for cleaning the piggery varies significantly according to the structure of the piggery. This point will be illustrated in more detail in the later part of this section.

Total waste water and its characteristics

According to differences in the structure of piggeries, the amount of water needed for cleaning the floor varies. In Taiwan, red brick and cement are commonly used and the amount of water used for cleaning the floor is about 5 to 15-fold of the amount of animal excreta.

If a pit is constructed below a slotted floor, there is no need to wash the floor and the wash water will be much less. If it is a trench style, the amount of water needed for cleaning can be controlled.

At the TLRI, the amounts of feces and urine produced by a hog with an average body weight of 60 kg are 1.32 kg and 3.12 kg, respectively, per day. The characteristics of the feces and urine are as follows: total solid, 34.5% and 0.25%; volatile solid, 25.7% and 0.15%; COD, 314,778 ppm and 7,493 ppm; BOD, 55,271 ppm and 3,016 ppm; total nitrogen, 8,619 ppm and 3,698 ppm; ammonia nitrogen, 767 ppm and 257 ppm; volatile acid, 14,882 ppm and 688 ppm.

Flush tank system of cleaning

The flush tank system was developed at the Michigan State University in 1970[4]. It has been used successfully for maintaining the cleanness of the piggery. This flushing tank system includes a) the water reservoir, which automatically controls the amount of water used and, b) the slanted pit under the slotted floor. This system has many advantages. The hog wastes drop to the slanted pit automatically and the wastes can be removed outside of the piggery so that the piggery can be kept odorless all the time. A minimum amount of water is needed to clean the slotted floor. The hogs are not directly in contact with the wash water, thus, the spread of pathogens is minimized. There is no electricity cost, and the labor cost is also minimum.

It is recommended that the flushing pit under the slotted floor should have a 2% slant. The surface of the pit should be smooth and painted with urine-resistant agents (polyurethane products). Most of the building contractors recommend to erode the surface of the pit with hydrochloric acid before painting. There should be at least 23 cm (9 inch) between bottom of the first slot and the surface of the pit in order to flush water smoothly.

The last six feet of the pit should be in pan shape in order to collect three-quarters of the washing water. There should also be a pipe with a diameter of 15 to 21 cm (6 to 8-inch) in order to drain all the animal wastes to the digester. In the gestation houses, farrowing houses and nursery houses, cleaning twice a day is sufficient to keep them free of odor. In the finishing houses, cleaning should be done three times per day by an automatic control system since those animals produce more wastes.

ANAEROBIC TREATMENT OF HOG WASTES WITH RMP DIGESTER

Usually a big area or space is required for the treatment of hog wastes, and the biogas produced through such treatment contains a considerable amount of water steam and hydrogen sulfide. Special attention should be given to the material used for the construction of the digester. The material should be inexpensive but resistant to erosion in comparison with cement, brick or sheet steel. The RMP invented by the UIRI is used by the Taiwan Livestock Research Institute (TLRI) and has proved to be a very good material for the digester.

The characteristics of RMP are as follows:

a) primary material: red mud and wastes from the aluminum industry.
b) physical properties: resistant to erosion by acid, alkali or salt solution. The results of aging tests are shown in Table 1.

A. The RMP Digester

The most recent model is shown in Figure 1 and is described below.

1. Input pipe

A 20 to 30 cm (8–12 inch) plastic pipe should be used for the input of wastes and should be immersed in the waste at least to 15 cm depth. This will prevent methane from being released.

The crude cellulose material is not easy to be digested and tends to block the entrance. Therefore, at the entrance there is a well which can be used to clean up the cellulose material before it enters into the swine digester.

2. Fermenter and gas storage bag

As indicated in Figure 1, the fermenter is the main component of the digester, and the gas storage bag is on top of the digester. The size of the fermenter is determined by the number of hogs times 0.3 m^3. For example, for 20 heads of hogs, we need a fermenter of 6 m^3. The fermenter should not be too big. If there is much waste to be treated, multiple chambers can be connected by plastic pipe. Usually, the efficiency of the multiple-chamber fermenter is better.

The RMP-built digester should meet the requirement of farmers. If the amount of hog wastes does not require a big fermenter, one single digester will be economical and practical. The multiple chamber-digester is more costly and elaborate to operate, but the efficiency of fermentation is better than the single fermenter. The multiple chamber-digester is more suitable for a big farm. The anaerobic fermentation can be divided into two stages: the first stage is acidogenesis which occurs during the first 12 to 24 hours, and the second stage is methanogenesis which occurs within 100–200 hours after the first stage. The size of the multiple chamber-digester can also be divided according to the two stages, one for acidogenesis and the other for methanogenesis. Since methane is produced at the second stage, the ratio of the size of two fermenters is about 1 to 8. On the other hand, the multiple chamber-digester provides more surface area, which may help to absorb solar energy. So the ideal model of RMP digester should be insulated, and there should be devices for heating and agitation. On the northern side of the digester, a soil wall helps prevent cooling by wind in the winter time. On the southern side of the digester, a simple solar energy collector is useful for heating during the winter. The constant temperature fermentation can thus be maintained.

The gas storage bag can be incorporated with the digester as one bag or can be separated from the digester as an independent bag. The gas storage bag can be installed near the kitchen. The biogas can be transferred over a long distance by the plastic pipe.

3. Effluent pipe

The diameter of the plastic effluent pipe is 4 to 6 inches and is located about 5 cm lower than the input pipe on the opposite side of the digester. The effluent pipe is also immersed into the fermenter to 15 cm depth in order to prevent the escape of methane through this outlet. Both the input and effluent pipes should be in fixed positions in order to maintain the constant inflow and outflow.

4. Methane pipe

On top of the biogas storage bag, there is a plastic pipe with a diameter of 2 inches. This pipe is used for transporting the biogas to its place of use. Near the digester the pipe has an outlet to its downward portion which can drain off the condensed moisture. This outlet is immersed in water as described below.

5. Safety device

A simple device is employed to prevent the breakage of the fermenter due to heavy pressure generated through anaerobic fermentation of the wastes. The methane outlet pipe near the digester is inserted into a bottle which contains at least 10 cm depth of water. When the pressure of the digester is greater than that of the water pressure, the biogas will be released.

6. Cleaning tubes

Some organic material settles at the bottom of the digester to form sludge, which has to be cleaned out once every two years. In Taiwan, the sludge may be cleaned out during heavy rains by blocking the effluent and letting large quantities of rain water flush through the digester and discharge all the sludge through this cleaning pipe. The sludge can also be removed by a pump. If the digester is very long, another cleaning outlet may be placed in the middle of the digester.

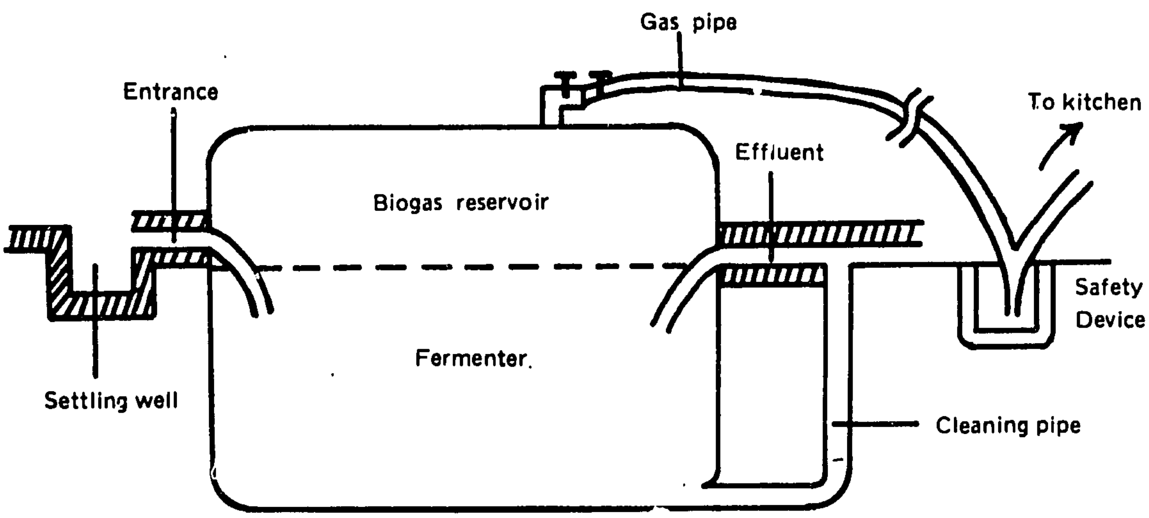


Fig. 1. Typical RMP digester

Table 1. Results of aging tests of red mud plastics*

Result	Aging test* duration: 0		837 hours (4 years)		1787 hours (8.5 years)		2500 hours (12 years)		3200 hours (15.2 years)		3517 hours (16.7 years)		4200 hours (20 years)	
	tensile strength (kg/cm^2)	elasticity (%)	tensile strength (kg/cm^2)	elasticity (%)	tensile strength (kg/cm^2)	elasticity (%)	tensile strength (kg/cm^2)	elasticity (%)	tensile strength (kg/cm^2)	elasticity (%)	tensile strength (kg/cm^2)	elasticity (%)	tensile strength (kg/cm^2)	elasticity (%)
Materials:														
Red mud plastic (RMP) 0.5 mm thick T-11	139.4	320	146.2	330	167	250	187.4	200	—	—	174.5	200	—	—
RMP 0.5 mm thick T-13	141.6	304	153.2	300	166	350	198.6	210	—	—	185.6	204	—	—
RMP 0.5 mm thick T-17	140.5	300	144	280	164.7	310	186.9	180	—	—	175.3	180	—	—
RMP 0.5 mm thick T-18	136.5	272	151.2	260	167.2	350	178.4	250	—	—	179.5	220	—	—
PVC 0.5 mm thick (13% of $CaCO_3$)	149	312	132.8	250	91.5—21.6 (fragile)	20.5	—	—	—	—	—	—	—	—
PVC transparent 0.5 mm T-20	114.3	374	116	340	87.5 (fragile)	120	—	—	—	—	—	—	—	—
RMP 1.2 mm thick C-20	173.8	344	—	—	—	—	—	—	160	320	—	—	158.5	260

* By using a Weather-0-Meter, at temperature 40—60°C, irradiated with an Arc for 51 minutes, sprayed with water for 9 minutes.

Installation

The installation of the swine waste digester is outlined in Figure 2. The first step is to prepare a pit appropriate for the digester. The size of the pit should be slightly larger than the digester. The input and effluent pipes should be attached after the digester is placed into the pit. After 3 to 4 days, the animal wastes can be discharged into the digester. The pit is usually filled with water before the animal wastes are discharged into the digester. The water surrounding the digester may help the digester to be expanded completely and lessen the tension which is exerted on the entrance and effluent pipes.

If the anaerobic digester is set up in the summer time, fermentation will be initiated immediately. In the winter time, inoculation of the digester with fermentation liquid from an old fermenter may [illegible] up the anaerobic fermentation.

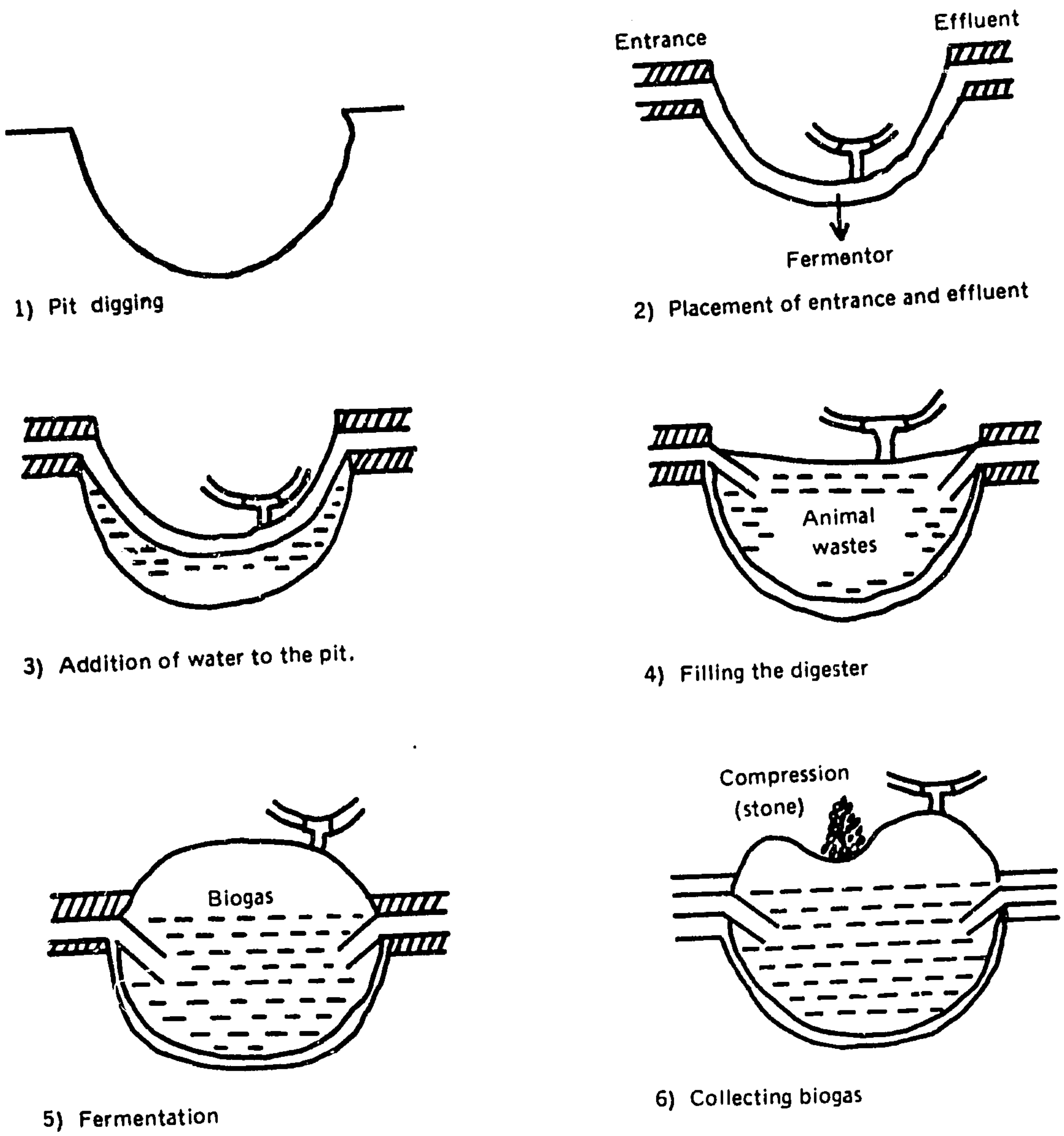


Fig. 2. Installation of RMP digester

Maintenance

As indicated in Table 1, the 1.2 mm thick RMP digester can be used for at least 20 years. No leakage has been detected since installation of this digester several years ago. Broken parts can be easily repaired. The area around the broken part should be cleaned and patched with a piece of RMP using a strong adhesive (Nanpo resin, Hyaoron NP 30 and hardening agent). The repaired part should be kept dry until it is completely hardened.

It is indicated that the effluent recycle will increase the methane production (5 to 10%) in the RMP digester[8]. The introduction of leachate (from vegetable or sweet potato vines etc.) into the methanogenic stage also results in increased methane production over the digesters without leachate. When methane is needed, a little pressure exerted on the biogas storage bag (i.e., placing a rock on top) will move the biogas to wherever needed.

The BOD of the effluent is only about 160 ppm. A small lagoon with water hyacinth will further reduce the BOD of the effluent.

There should be another water outlet right before the entrance to prevent the rain water from entering the digester during the rainy days.

The Anaerobic Lagoon with RMP Cover

In the United States, the treatment of piggery waste can be summarized as follows: a) slotted floor ⟶ oxidation ditch ⟶ lagoon; b) slotted floor ⟶ pit ⟶ lagoon, or; c) piggery ⟶ lagoon. We can see that the lagoon is used for each kind of treatment of piggery wastes.

There are several advantages of using the lagoon for waste treatment. The lagoon system is simple and inexpensive. The maintenance cost is minimum. In the United States each farmer owns more than 50 acres of land so the space requirement for the lagoon is not a problem. Since Taiwan is a small island, agricultural land is limited. Using space for lagoon is uneconomical on the one hand. On the other hand, there are some defects of the lagoon system. For example, pollution of the underground water and odor from the piggery wastes are two of the more serious problems.

The space requirement of lagoon for each pound of hog is 2 ft^3. For example, for a farm with 100 head of hogs, the size of the lagoon should be 2 ft^3 x 100 x 200 = 40,000 ft^3 = 1,200 m^3; that is, for every 100 head of hogs, a 1,200 m^3 lagoon is needed. If a RMP cover is placed on top of the lagoon to form an anaerobic lagoon, the odor and flies on the animals wastes can be eliminated. The anaerobic lagoon should not be built on sand or limestone soil but on impervious soil. If under special conditions the lagoon has to be built on sand or limestone soils, a distance between the lagoon and the nearest well should be at least 45 meters.

At the University of Illinois, Champaign-Urbana, there is an anaerobic lagoon 15 m by 30 m by 1.5 m with a plastic cover. A pipe is constructed on top of the cover, and methane is thus recovered.

UTILIZATION OF METHANE

Methane can be used for various purposes. Singh measured the amount of methane required for different purposes.

According to Singh[14], about 0.4 m^3 of methane is needed per person per day (calculated for cooking food and water). For a family of five persons, 2 m^3 of methane per day is sufficient. According to the estimation of Chung *et al.*[1] 0.3 m^3 of methane will be produced per day from the wastes of 90 kg hog. These data are in agreement with the practical case on a small farm in Taiwan. During warm seasons, for a family of five, 7 head of hogs will provide sufficient methane for household fuel. In winter when temperature is below 22°C, the amount of methane produced is below the need of a family of five.

Si methane is not easily stored, it is better to use methane where it is produced. Methane can be transferred through pipes. With an air pump and constant pressure at 4 kg/cm^2, the methane can be transported to any distance.

Because of the inexpensive RMP, the production of methane from hog wastes through the anaerobic digester is quite worthwhile. For the treatment of wastes from one hog, a 0.5 m^3 RMP bag costs only about NT$300. This amount of investment can be recovered within 5 to 9 months.

The TLRI has modified the water heater which consumes methane[10]. It can replace the propane gas completely. The result is shown in Table 2. Water pumps can also be operated on methane instead of gasoline as direct fuel, but the carburetor of the water pump has to be modified. In a test conducted at the TLRI, a 5-horse power engine fitted to a 4-inch water pump consumes 2.1 m^3 of methane per hour to pump out 34.1 m^3 animal wastes for irrigation. In other words, for every cubic meter of methane, 16.3 m^3 animal wastes can be pumped.

The TLRI also conducted a test to generate electricity by methane. The carburetor of the engine should be replaced with a modified inlet which can be operated on methane[9]. The modification of the carburetor is shown in Figure 3. Using methane to generate electricity is quite applicable with a small engine. The largest engine tested was 25 KW.

Due to the presence of hydrogen sulfide and saturated steam in this biogas, the engine can easily rust. Special attention should be given to prevent the engine from corrosion. Elimination of hydrogen sulfide will certainly be helpful. Usually a small amount of gasoline will help eliminate this problem. At the TLRI one engine has been used for four years and no problem so far has been detected.

Table 3 lists the quantitative relationship between the amount of methane consumed and the electricity generated by using 2 KW, 10 KW and 25 KW engines[16].

1US$ = NT$ 36.

Table 2. Amount of methane consumed for water heater*

Item	Temperature of water (°C)				
	40	50	60	75	90
Amount of water heated (l/min)	17.4	9.4	7.0	4.9	2.9
Amount of methane consumed (l)	34	60	114	180	197

* The test is done at air temperature of 29°C and water temperature of 27°C

Table 3. Relationship between amount of methane consumed and electricity generated

Engine	Amount of methane consumed per hour (M^3/hr)	Electricity generated (KW)	Amount of methane consumed for each kwh of electricity (M^3)
2KW*	0.95	1.2	0.792
10KW*	9.00	9.5	0.947
25KW**	22.50	25.0	0.900

* An old engine ** A brand new engine

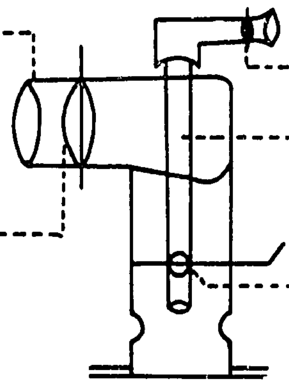


Fig. 3. Modified inlets for methane driven generator[9]

CULTURING OF ALGAE

The effluent from the RMP anaerobic digester contains a significant amount of nitrogen, phosphorous and potassium, which can be used to cultivate algae. Algae provide a high protein source for animals. Besides, the BOD can be further decreased by the growing algae. The BOD of effluent from the lagoon of algae will, therefore, be reasonably low, which meets the requirement of the water pollution control. Two examples will be discussed here: one is a farm at Ellinwood, Kansas, where green algae is cultivated by the effluent of an anaerobic lagoon; the other is the cultivation of blue-green algae from the effluent of RMP anaerobic digester at the Tainan Fish Culture Station of Taiwan Fishery Research Institute (TFRI).

A. Cultivation of Green Algae

There are three piggery buildings with a total number of 2,600 head of hogs. One-third of the floor of the piggery is slotted and the other two-thirds is cemented. There are five lagoons. The hog wastes are discharged to the first three lagoons for anaerobic fermentation. The fourth and fifth lagoons are used for the cultivation of green algae. The pea-soup (wet algae) or the dried algae are used for animal feed. The first lagoon receives the hog wastes from the piggery, the hog wastes then overflow to the second lagoon. The waste water and well water are then pumped into the third lagoon with a ratio of 3 to 5. Then, the wastes are introduced to the 4th and 5th lagoon and inoculated with the green algae. The color of the wastes in the third lagoon is red orange. It takes about 65 to 85 days for the growth of algae before they can be harvested. During harvest the algae are precipitated in a

…,500-gallon chamber to which aluminum hydroxide is added. The precipitated algae is then pumped to a storage tank which is transferred to the piggery for feeding. The supernatant is repumped into the lagoon. The harvested wet algae contain 10% of dry weight. The wet algae can be dried with solar energy to form powder (Grant, R., Personal communication).

According to the report of the owner of the farm, when the green algae are included in the hog feed, the feed intake increases 20 to 25%; the daily gain of hogs increases by 40% and the feed efficiency increases from 3.2 to 2.8. The cost for harvesting one gallon of wet green algae (dry weight 10%) is only US$0.01–$0.02, and most of the cost is for electricity.

A test on using green algae as hog feed was also conducted at the Chang-Hua branch station of the TLRI. The green algae is cultivated in the open lagoon which is filled with the effluent from the anaerobic digester. The dried weight of the green algae is only 5%. Green algae were substituted for soybean oil meal and corn (2.5% and 10% of algae by dried weight) as feed for hogs from 31 to 90 kg. Statistically, there was no significant difference in weight increase in these hogs in comparison with hogs fed with soybean oil meal and corn only (Chen, C.T., Personal communication).

B. Cultivation of Blue-green Algae

Spirulina platensis (a kind of blue-green algae) contains about 57.5% protein as analyzed by TLRI. Tables 4 and 5 show the composition of *S. platensis*. The effluent from the anaerobic digester is a good nutrient which can be used to cultivate spirulina better than the chemical fertilizer. The results of experiments carried out at the Tainan Fish Culture Station of TLRI are shown in Figure 4, Tables 4 and 5.

Two lagoons installed with RMP sheet, 32 m by 8 m by 0.3 m were used for cultivating *S. platensis*. At the beginning, the lagoons were filled with well water to 12 cm in depth, then inoculated with the suspension of spirulina to 3.4 cm in depth. The effluent from anaerobic digester was slowly conducted into the lagoon to maintain the NH_3-N content in the water at 5 ppm, and the pH was kept at 8.5 to 10.5. For example, if the effluent contains 500 ppm NH_3-N, then to a 32 m x 8 m lagoon with 15 cm depth of water (38,400 liters), 384 l effluents must be added (38,400 l x 5 ppm ÷ 500 ppm) per day. Besides, the salinity content is also a very important factor for cultivating spirulina. According to the experiment, the spirulina grows better in 20% salinity than 10% salinity or none. The result is shown in Figure 5.

The growth of the blue-green algae is measured with spectronic 20 (560 mm). Usually it takes about 2 weeks for the optical density (O.D.) to reach 1.0 or above. When the O.D. reaches 1.0 or above, the spirulina is ready for harvest. A lagoon of 32 m x 8 m x 0.3 m produced 9.7 g (dry weight) of blue-green algae in one square meter area per day in summer time, and 7.3 g in winter time. The experimental result is shown in Table 6. Since this is an open lagoon, water will evaporate and frequent addition of water is necessary in order to keep the water volume constant.

Since the blue-green alga is an aerobe, aeration with a one-horsepower engine of 26 rpm was employed. When aeration stops, the blue-green algae suspend on top of the lagoon and can be picked up with a harvest net. The algae suspension can also be picked up into a big container with a filter (harvest net) to hold the blue-green algae and allow the water to pass through.

The preliminary experiment on the cultivation of blue-green algae with the effluent of anaerobic digester seems very successful. The blue-green algae not only serve as good feed for fish, but can also be consumed by hogs. Several experiments concerning the cultivation and the utilization of blue-green algae are still in progress.

Table 4. The composition of *Spirulina platensis** (%)

Sample	Item								
	Dry matter	Crude protein	Crude fat	Crude fiber	Nitrogen free extract	Ash	HCL insoluble	Calcium	Phos-phorus
Fermented manure medium	10.42	57.44	2.84	2.21	28.91	7.87	0.73	0.13	0.45
Chemical medium	7.60	57.62	4.58	3.61	23.00	9.58	1.61	0.05	0.54

* On dry weight basis

Table 5. Amino acid composition of *Spirulina platensis*

Amino acid	g/100g crude protein
Arginine	4.905
Histidine	1.498
Isoleucine	2.259
Leucine	9.972
Lysine	4.591
Methionine	0.721
Phenylalanine	4.555
Threonine	5.735
Valine	7.586
Cystine	Trace

Table 6. The production of *Spirulina platensis** in different media

Media		Production g/day/m^2 (dry wt.)	
		Summer	Winter
Fermented manure	5 ppm	9.72	7.30
(NH_3-N)	10 ppm	3.85	3.40
Chemical		9.50	8.45

* The summer temperature is 26.25 (21.7–30.8)°C; whereas the winter temperature is 17.3 (15–19.6)°C.

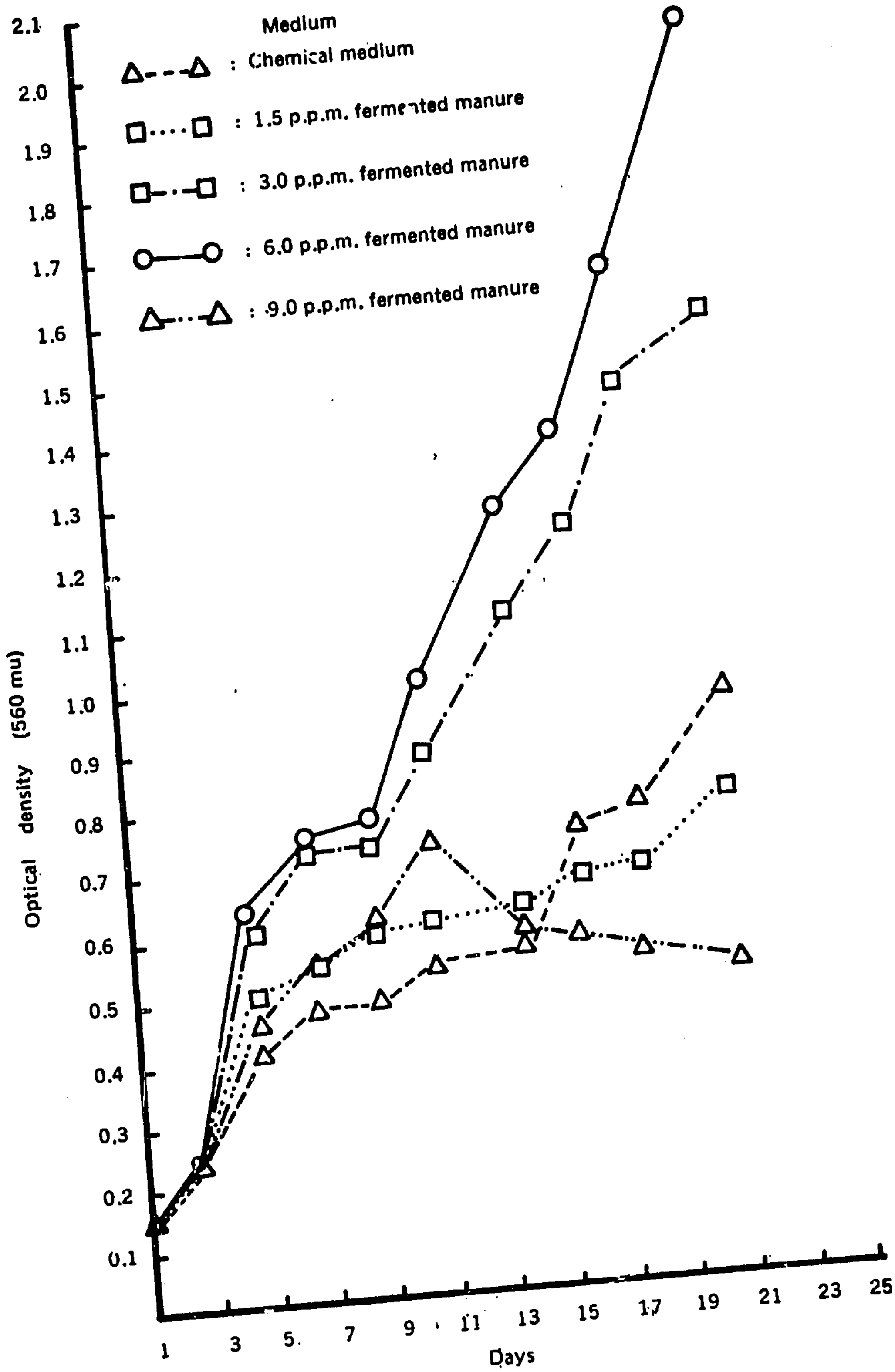


Fig. 4. The growth of *Spirulina platensis* in chemical medium and in fermented hog manure

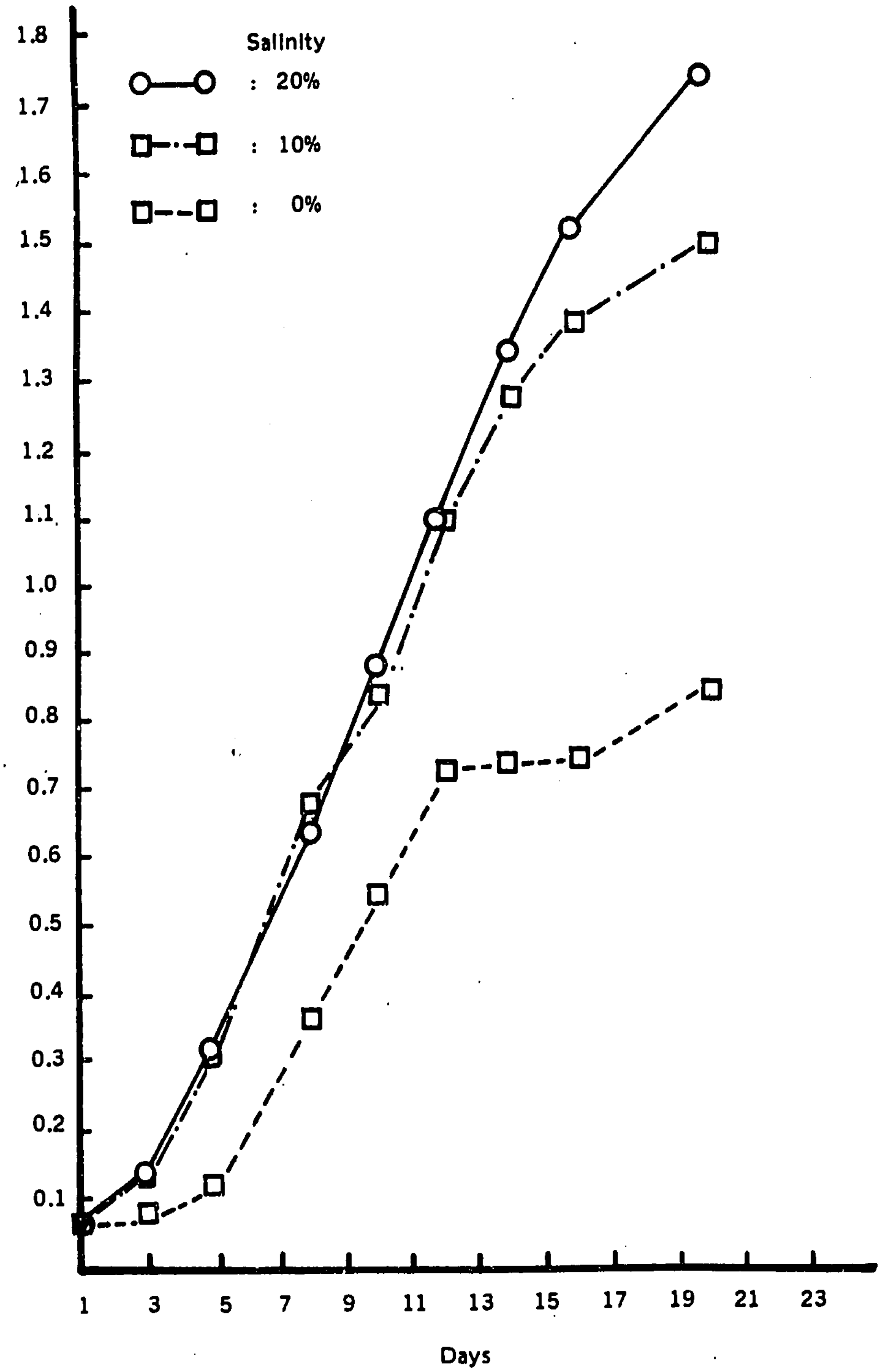


Fig. 5. The effect of salinity on the growth of *Spirulina platensis* with fermented hog manure.

REFERENCES

1. Anaerobic Manure Lagoons, Agricultural Engineers Digest 1969. Midwest Plan Service. Ames, Iowa.
2. Cheng, S. H., and C. P. Wang. 1977. Experiment on the Fertilizing Effect of Hog Manures after Treatment of Fermentation in the Methane Generator in Corn and Sorghum. Taiwan Prov. Dept. of Agric. and For. (in Chinese).
3. Chung Po, H. H. Wang, S. K. Chen, C. M. Hong, and C. I. Chang. 1975. Small Methane Generator for Waste Disposal. Proc. of the Third International Symp. on Livestock Wastes. American Society of Agric. Engineers, St. Joseph, Missouri.
4. Flusing. 1975. Elevision Bull. E-777. Michigan State University.
5. Furuhashi, K. 1977. The Relationship Between the Nutritional Level and Quantity of Hog Excreta (1). Animal Husbandry 31: 737–740. (in Japanese).
6. Hong, C. M., M. T. Koh, and Y. H. Tsai. 1976. Study on Methane Gas Generators for Hog Waste Disposal. Jour. of the Taiwan Livestock Res. 9: 29–37. (in Chinese).
7. Huang, T. J., and Y. C. Lee. 1974. Studies on the Pathogenicity of Fermented Swine Excretas (II). The Parts of Bacteria and Viruses. Taiwan Prov. Dept. of Agric. and For. (in Chinese).
8. Johnson, Jr. A. L. 1976. Final Report on Research in Methane Generation. The Aerospace Corporation EI. Segundo, Calif.
9. Koh, M. T. 1979. Utilization of Methane for Generation of Electricity. Taiwan Prov. Dept. of Agric. and For. (in Chinese).
10. ———— and C. M. Hong. 1977. Studies on the Application of Methane. Taiwan Livestock Res. Inst. (in Chinese).
11. Lee, Y. C., and C. P. Wang. 1974. A Study on the Zoonotic Pathogenicity of Swine Manure After Treatment of Fermentation in the Methane Generator. Taiwan Prov. Dept. of Agric. and For. (in Chinese).
12. McCarty, P. L. 1964. Anaerobic Waste Treatment Fundamentals, Part one-Chemistry and Microbiology. Public Works for September, 1964.
13. O'Callaghan, J. R., V. A. Dodd, P. A. J. O'Donoghue, and K. A. Pollock. 1971. Characterization of Waste Treatment Properties of Pig Manure. Jour. Agric. Eng. Res. 16:399–419.
14. Singh, R. B. 1971. Bio-gas Plant: Generating Methane from Organic Wastes. Azitmal, Etawah (U.P.) India, Gobar Gas Research Station.
15. Taiwan Agriculture Year Book, 1966–1979. Taiwan Prov. Dept. of Agric. and For. (in Chinese).
16. Wang, H. H., T. H. Liu, C. M. Hong and M. T. Koh. 1976. Special Report on the 2nd National Conf. on Waste Water Treatment.
17. Yen, T. T., and C. P. Wang. 1974. On Some Properties and Contents of Plant Nutrients of Hog Manures After Methane Fermentation. Taiwan Prov. Dept. of Agric. and For. (in Chinese).

PRE-FEASIBILITY STUDY : GROUP I

INTEGRATED CROP-LIVESTOCK-FISH FARMING WITH CROP AS THE MAJOR ENTERPRISE

INTRODUCTION

The crop-based farming enterprise is intended for a group of 100 farmers with total landholdings of 100–200 hectares. This project works on the assumption that these farmers utilize low technology for rice growing and they do not raise fish and own only draft animals and very few head of chicken. Hence it aims to improve the nutritional status and to increase the averaqe income of these farmers. Assuming that majority of the farmers in the rural areas are engaged in rice production, these rural farmers earn only US$580 average income versus US$1,058 for the urban folks.

Based on the availability of water and farmers' resources, soil condition and capability of the farmers four patterns are identified, namely: 1) irrigated rice paddv-fish-livestock, 2) rainfed crops-fishpond-livestock, 3) upland rainfed crops-livestock, and 4) special case.

Inclusion of fish as part of an enterprise is primarily determined by the availability of water throughout the year. In irrigated rice paddy, fish can be continuously raised, while for rainfed, it may be rotated with rice. Livestock can easily fit in any of the patterns.

Considerinq the two general objectives of the project, four criteria in the selection of the most suitable pattern(s) for the area are set:

1. Technical feasibility

The package of technology should be sound and applicable to the farmers' agro-climatic and socio-economic setting to prevent resistance in acceptance.

2. Analyses of production measures

To improve further the yield of rice, species and cultivars, cultural management especially fertilizer and chemicals, harvesting and storage, by-product utilization for fish and livestock and planting of fruit trees and/or crops along the side of the fish ponds are considered.

Since fish and livestock will be new introductions, only a small space (e.g., 0.2–0.5 ha) may be devoted to fish pond with either tilapia or mudfish. The number of livestock such as chicken, ducks, geese, sows, cattle/carabao and goat will depend on the amount of excreta that will be available for feeding of the fish in the pond.

3. Marketing situations

Convenient transportation facilities, system of marketing (either cooperative or middleman on contract basis), presence of collection center, storage/container facilities and market information service like radio could be made available to the farmers.

4. Investment estimates

It is assumed that the farmers can obtain loan and grant from the government in the form of improvement of roads and provision of water supply.

The investment estimates and the additional incomes derived from the improvement of the rice technology, and from the inclusion of fish and livestock are indicated in Table 1.

In this feasibility study, the small group of farmers would have a 44% net return from their investments after a year.

Table 1. Investment per year for individual farms and 100 farms

Items	Grant (US$)	Loan (US$)
Crop		
Seed		30
Fertilizer		200
Chemicals		70
Equipment implement, pump and engine	100	200
Land proparation and harvesting		50
Sub-Total	100	550
Fish		
Fingerling		50
Fishpond (0.5 ha)	150	300
Sub-Total	150	350
Livestock		
Feeds (12 bags), 1 bag/month consumption		300
Chicken (20 hens)		5
Duckling (40)		13
Geese (100 goosellngs)		7
Pig (1 gilt)		33
Carabao or cattle		330
She-goats (2)		12
Sub-Total		700
TOTAL PER FARM	250	1,600
Public Facilites (for 100 farmers)		
Water supply (well)	2,500	
Communication (road)	5,000	
Storage, drying (controlled drying shed)	5,000	5,000
TOTAL	12,500	5,000

Table 1a. Investment and return per year

Items	Per farm		100 farms	
Total investments (US$)	Grant	Loan	Grant	Loan
Per farm	250	1,600	25,000	160,000
For the group			12,500	5,000
Sub-Total			37,500	165,000
TOTAL			202,500	
Additional income due to the project (US$)				
Crop	150		15,000	
Fish	500		50,000	
Livestock	250		25,000	
TOTAL			90,000	
	90,000/202,500 = 44%*			

* Return rate = $\frac{\text{Total investment}}{\text{Additional income}} \times 100$

Note: Income from fish may be US$1,000 if production rate of 2,000 kg/ha and a market price of US$ 1 per kg are assumed.

PRE-FEASIBILITY STUDY : GROUP II

INTEGRATED CROP-LIVESTOCK-FISH FARMING WITH LIVESTOCK AS THE MAJOR ENTERPRISE

INTRODUCTION

There was considerable discussion as to exactly how this study should be approached; whether it should be general or written in specific detail. It was decided that as the group had little common knowledge on a specific area, a more generalized approach would be taken. There was general agreement that the study should be directed at the small family farmer who is in greater need of help than the larger, already commercially oriented operator. The long term effects must be considered, for the whole society as well as for the individual farmer. The system devised should ensure the elevated productivity of the land in perpetuity with outside inputs carefully regulated. The only inputs in a perfect system would be sunlight (energy) and water. This approach encourages the use of recycling systems and multiple land use rather than unstable monoculture systems which by their nature require large inputs from outside the system. The point was made that cooperative ventures such as feed mills, abattoirs and nurseries may give rise to effluent or by-products which could and should be used in recycling systems by the cooperating farmers.

Comment was made on the increasing use of insecticides and pesticides and it was noted that unless this practice is very carefully controlled it could lead to catastrophic imbalances in the ecosystem and result in such undesirable effects as the destruction of all fish in the fish ponds. There may also be serious risks to human health if pesticide residues become incorporated in the food chains, e.g. eggs, meat, milk or fish.

There was final agreement that uppermost in the average small farmer's mind would be self-sufficiency and only after that would he be interested in 'cash cropping' to earn income to pay for the so-called business of life.

ASSUMPTIONS

The following assumptions were agreed upon for the purpose of this stu

1. Rainfall: 3000 mm per anum with monsoonal distribution
2. Soil type: volcanic soils of a clay-loam type
3. Topography: moderately rolling
4. Size of farm: 1.5 ha
5. Availability of labor: 10.5 man-days per 6-day week
6. Local market situation: village of 5,000 persons
7. Transport facilities: unsealed feeder road to village which is cut during the monsoonal period
8. Credit facilities: Rural Bank loans of up to US$600 available at 12% interest with minimum collateral requirement

RESULTS OF GROUP STUDY

Members of the group had considerable difficulty in tackling this very complex problem. It was agreed that computer modelling and partial budget analysis techniques would be a very appropriate way of looking for the correct solution in any specific area. This would of course depend upon that model being based on the correct assumptions and containing accurate specific parameters.

The group produced two reports which are outlined below. The first one follows a very general approach while the second goes into some detail of an approach which might be taken.

CASE I

Of the total land area

0.9 ha (60% of total) will be used for paddy rice production
0.45 ha (30% of total) will be used for dry land farming
0.15 ha (10% of total) will be used for vegetable garden for family subsistence and include a fish pond.

1. Paddy Cultivation – 2 crops per year

   Production would include:

   Rice – for commercial sale
   Straw – for animal feed (cattle) and for composting
   Bran – for pigs and poultry

2. Dry Land

   Wet season – grow vegetables for sale, and upland rice
   Dry season – grow corn for feeds to animals and for sale.
   Corn stems to be used for cattle feed.

3. Pig Enterprise

   Major livestock enterprise

4. Duck Enterprise

   Based on pond production and piggery effluent

5. Fish Enterprise

   Animal effluent used to fertilize pond. Pond would be used as source of water for garden in the dry season.

   Small fish unsuitable for sale could be fed to the pigs. In dry season, silt from the bottom of the pond would be used as fertilizer for vegetable garden.

6. Biogas

Animal manure would be anaerobically fermented for gas production to be used for cooking and light.

7. Cattle

Buffalo, which would be used as draught animals, will be used in this system.

CASE II

1. Rainfall

Dry : November–December
Wet : June–October

2. Piggery-rice Farm

3. Resource Requirement

(a) Land
Rice – 1.5 ha, 1 crop season, wet
Corn – 1.5 (2 crops) – 3.0 ha, dry season
Hogs – 200 m^2

(b) Labor

Rice – 77 mandays
Corn – 100 mandays
Hogs – 243 mandays

4. Resource Supply

(a) Labor – 546 mandays/year
(b) Land – 1.5 ha, absolute
(c) Capital – Own capital – ₱ 5,000
Borrowed capital – ₱ 37,500

5. Farm Privileges

(a) Rice – 167 kg palay
(b) Corn – 170 kg
(c) Pig – 43 kg (1 pig)

6. Inputs

(a) Hog feeds – 23,300 kg (₱ [illegible],000) commercial feeds
23,300 kg (₱ 7,800) local feeds

(b) Fertilizer

Rice –	6 bags N –	₱ 720
	2 bags P –	200
	2 bags K –	180
Corn –	5 bags N –	600
	2 bags P –	200
	2 bags K –	180
		₱ 2,080

(c) Chemicals

Rice –	₱ 300
Corn –	200
Hogs –	300
	₱ 800

(d) Hired labor

Rice –	for plowing	₱ 240
	for weeding	120
	for harvesting	1,200
		₱ 1,560
Corn –	for plowing	₱ 150
	for weeding	100
	for harvesting	500
		₱ 750

7. Output

Rice – 120 cavans	₱ 7,200
Corn – 100 cavans	5,000
Hogs – 80 (80 kg each)–6400 kg	44,800
	₱ 57,000

8. Financial Analysis

Gross Income

Hogs	₱ 44,800
Rice	7,200
Corn	5,000
TOTAL	₱ 57,000

Cost of Production

Hog feeds	₱ 35,000
Chemicals	800
Hired labor	1,500
Fixed cost (12% of total cost)	4,450
Interest	4,507
Total cost	46,257
NET INCOME	10,743

Benefit/cost ratio: 1.23:1

1US$ = ₱ 7.35

PRE-FEASIBILITY STUDY : GROUP III

INTEGRATED CROP-LIVESTOCK-FISH WITH FISH AS THE MAJOR ENTERPRISE

INTRODUCTION

In determining the fish-based tricommodity integrated farming, several factors like production systems, processes and culture techniques and marketing analysis are considered. The study would be on a one-hectare farm located in an area with a population typical of rural community. Freshwater is assumed to be available throughout the year for fishpond operation. Culture methods involved would be the monoculture and polyculture systems with Nile tilapia and Chinese carps as the predominating species. Pig pens would be constructed strategically on top of the fishpond. Vegetables such as Kangkong (*Ipomea reptans*) and sweet potato (*Ipomea batatas*) would be grown alongside of the dikes for maximum utilization of available space, for added production inputs and for protection of dikes against erosion.

Basins or tabs would be used for the fishes and fishing nets would be obtained for seining. Other standard farm equipment would be bought for garden use such as rake, pork, shovel, etc.

THE FEASIBILITY STUDY

The farm would be near the busy market of the village where all supplies and materials could be obtained easily without any constraints to the fish farmer. Since fish is the major enterprise, a stand-by pump of 2 horsepower is assumed to be available for emergency continuous water supply. In a monoculture system, the stocking rate of tilapia is 20,000 to 25,000/ha/year with an 80% survival rate, while carp is 8,000/ha/year with 60% survival rate. For the polyculture system, the stocking rate of tilapia and carp would be 17,000/ha/year, and 3,000/ha/year or 85% and 15%, respectively. There is no problem in the combination of these two species since tilapia are omnivorous species while carps feed mainly on benthic organisms. The depth of water in the fishpond would be maintained at 1.0–1.5 meters.

Pigs pens made of wooden or bamboo floors would occupy 100 m^2 on top of the pond divided into four units which are independent of each other. These pens would be sloping towards an outlet for hog manures and other waste products which would serve as fertilizers for the fish. On the average, about 5 kg/day/hog or 500 kg/day would be disposed for the 25,000 fish. One kilo of tilapia would require at least 18 kg of hog manure for growth sustenance. It is assumed that 100 pigs/cropping/year would be enough for the small-scale farming system. In addition, vegetables would be grown along the 1.0 m wide dikes to serve as food partly for human consumption and partly for the pigs and fishes. Disease of the animals and the cultured species is assumed to be minimal so that it is not a problem to the farmer himself.

Figure 1 presents the flow chart of the various inputs and outputs in an integrated crop-livestock-fish farming system. At US$ 1.0/m^3, fishpond construction will cost around US$ 10,000. Pig stalls made of bamboo or wood would cost US$ 10,000 at US$ 100/m^2 in a 100 m^2 pig pen area (Fig. 2).

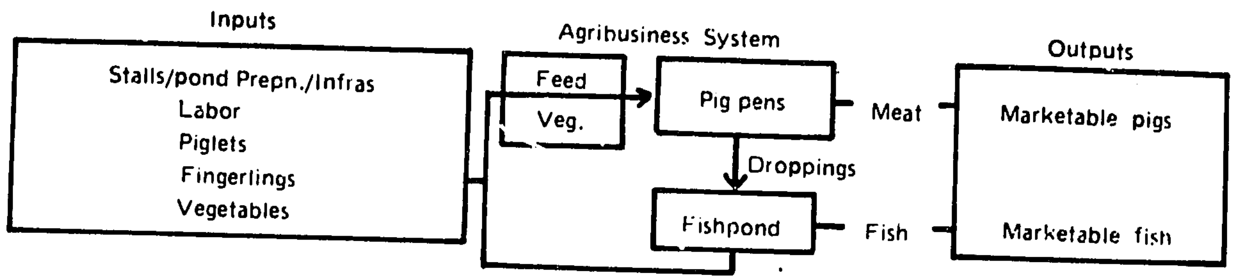


Fig. 1. Flow chart of the production systems

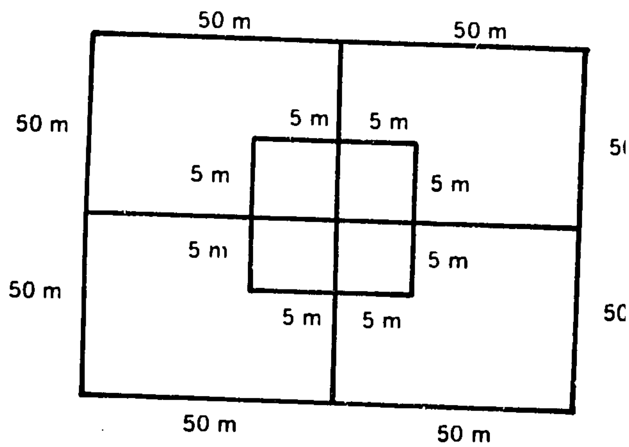


Fig. 2. Design of fishpond and location of pig pens

For operational cost, tilapia fingerlings would be obtained at US$ 15.0/1000 with a total of US$ 600 to be incurred for 2 croppings/year. Piglets could be bought at US$ 30.0/head for a total of US$ 6,000 for 2 croppings/year. Vegetables' cost is assumed to be at US$ 100; hog feeds at US$ 20/pig/day for 300 days would cost around US$ 6,000. Other operational costs would include medicine and miscellaneous expenses estimated at US$ 1,000 and labor inputs at US$ 2,400 (US$ 800 man-day/year at US$ 3/man-day). Assuming a 10% mortality rate, 0.3 kg of tilapia would be sold at US$ 1.0 and a gross income of US$ 10,800 would be realized for 2 croppings. Hogs would be sold at US$ 1.2/kg. live weight of pigs. Thus at 90 kg and 98% survival rate, an income of US$21,168 would be obtained from hogs. Annual cost is assumed within a 4-year duration and at 10% rate of interest. The probable operation of pigs would be:

1.	January – February	50*
2.	March – April	50* + 50 = 100
3.	May – June	100 + 50 – 50** = 100
4.	July – August	100 + 50* – 50** = 100
5.	September – October	– do –
6.	November – December	– do –

* Newly-bought piglets
** Pigs for sale

The probable problems that have been considered are the occurrence of flood, typhoons, pollution or fish kills from pesticides and diseases.

Cash Flow (US$)

	Year				
	0	1	2	3	4
Inflow					
Loan value	36,100	–	–	–	–
Production value	–	30,300	30,300	30,300	30,300
Total	36,100	30,300	30,300	30,300	30,300
Outflow					
Infrastructure					
Ponds and dikes	10,000	–	–	–	–
Pens	10,000	–	–	–	–
Feeds	6,000	6,000	6,000	6,000	6,000
Stocks					
Piglets	6,000	6,000	6,000	6,000	6,000
Fingerlings	600	600	600	600	600
Vegetables	100	–	–	–	–
Labor	2,400	2,400	2,400	2,400	2,400
Medicine and misc. items	1,000	1,000	1,000	1,000	1,000
Loan repayment					
Principal	–	9,025	9,025	9,025	9,025
Interest	–	3,610	2,707	1,805	902
Total	36,100	28,635	27,732	26,830	25,327
Net inflow	–	1,665	2,568	3,470	4,373

Estimated Expenses and Returns (US$)

A. Infrastructure

Fishpond construction	– 1.0 x 10,000 m^2 x $1.0	= 10,000 (Human labor)
	–	= 5,000 (Machinery)
Pig stails	$100 x 100 m^2	= 10,000
	TOTAL CAPITAL COST	$ 20,000/15,000

B. Annual Operation

Cost of piglets	– $30 x 100 heads x 2 croppings/yr.	= 6,000
Cost of fingerlings	– $ 15/1000 x 20 x 2	= 600
Cost of vegetables	–	= 100
Cost of hog feed	– $ 20/hog x 300 days	= 6,000
Medicine + misc. items	–	= 1,000
Cost of labor	– $800 man-day/yr. x $3.0/man-day	= 2,400
	TOTAL OPERATING COST	$ 16,100

C. Sale of Pigs	– $1.2/kg x 90 kg x 200 heads x 0.95	= 21,168
Sale of fish	– $1.0 x 0.3 kg x 20,000 x 0.90 x 2	= 10,800
	GROSS INCOME	$ 31,968
D. Net Profit		$ 868

PARTICIPANTS

AUSTRALIA

Peter J. Carroll
Animal Production Center
Hawksbury Agricultural College
Richmond N.S.W. 2753

JAPAN

Tadashi Tenma
Department of Agricultural Economics
Obihiro University of Agriculture and Veterinary Medicine
Inada-Cho, Obihiro City, Hokkaido

KOREA

Youl-Mo Dong
Office of Rural Development
Ministry of Agriculture and Fisheries
Suweon

MALAYSIA

Ong Kee Bian
Inland Fisheries and Aquaculture Branch
Agriculture Headquarters
Kuching, Sarawak

Ali Bin Ismail
Fisheries Department
Ministry of Agriculture
Jalan Swettenhan, Kuala Lumpur

PHILIPPINES

Diosdado Carandang
Department of Soil Science
University of the Philippines at Los Banos
College, Laguna

Catalino de la Cruz
Central Luzon State University
Munoz, Nueva Ecija

Moises R. de Guzman, Jr.
Department of Animal Science
University of the Philippines at Los Banos
College, Laguna

Carlos Fernandez
Development Academy of the Philippines
P. O. Box 5160
Makati, Metro Manila

Joseph C. Madamba	Asian Institute of Aquaculture/Southeast Asian Fisheries Development Center Tigbauan, Iloilo
Felix Maramba, Sr.	Liberty Flour Mills, Inc. Liberty Bldg., Pasay Road Makati, Metro Manila
Elvira O. Tan	Philippine Council for Agriculture and Resources Research Los Banos, Laguna
Edward Tayengco	Southeast Asian Regional Center for Graduate Study in Agriculture College, Laguna

TAIWAN

Huang Chia	Animal Industry Division Council for Agricultural Planning and Development 37 Nanhai Road, Taipei
Chia-Mo Hong	Taiwan Livestock Research Institute Hsinhua, Tainan
Meeng-Ter Koh	Taiwan Livestock Research Institute Hsinhua, Tainan
Chaur-Shyan Lee	Research Institute of Agricultural Economics National Chung-Hsing University Taichung

THAILAND

Somsak Janesirisak	National Inland Fisheries Institute Kasetsart University Campus Fisheries Department Bangkok 9
Reynaldo Lesaca	United Nations Environmental Program Regional Office United Nations Bldg., Bangkok Thailand
Thunya-Udon Boripat	Kalasin Research and Training Center UNDP/FAO/74/015 P. O. Box 7 Kalasin, Thailand

FFTC STAFF

Carson Kung-Hsien Wu	Director ASPAC-FFTC Taipei, Taiwan, ROC
Milagros H. Tetangco	Information Officer ASPAC-FFTC Taipei, Taiwan, ROC